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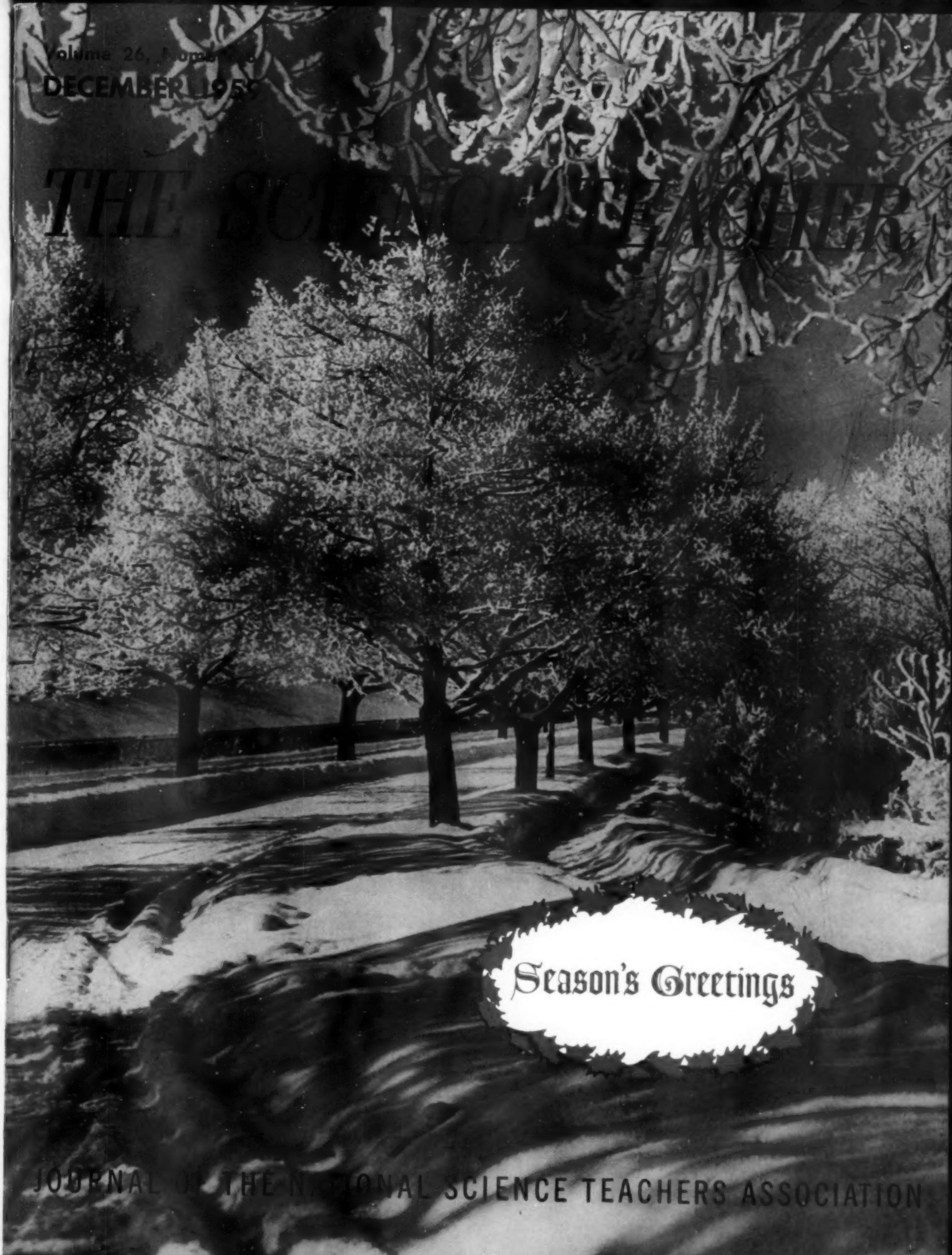
DECEMBER 1959

THE SCIENCE TEACHER



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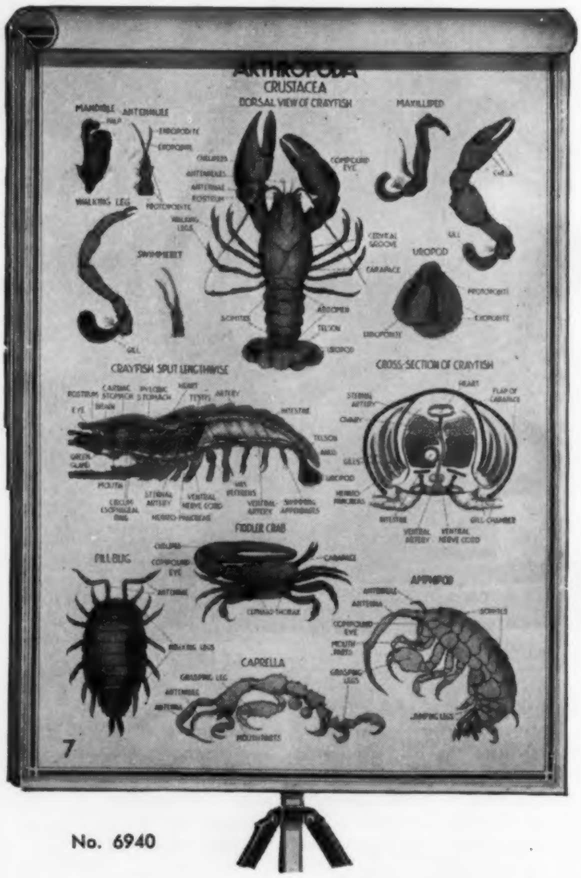

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The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Volume 26, Number 8 December 1959

Editor's Column

Some science teachers in the elementary and secondary schools may not have been properly credited for a unique service which they performed for educators. Science teachers were the ones who first met head-on the tumultuous pressures to "up-grade," "add to," or "make harder" what they were teaching. These people almost overnight were in the unenviable position of being too popular.

Soon mathematics, social studies, and modern foreign language teachers were faced increasingly but in a less hectic atmosphere with the same pressures. Today, as each of us proceeds with our daily tasks, we too are working to meet the challenge issued months earlier to science teachers—how to work toward balance in the curriculum?

Before noticeable progress can be made in meeting this challenge three concerns must be faced. First, a rationale for decision-making must be determined before answers can be found to: what is to be taught, to whom, by whom, and for how long a time, both in the daily schedule and throughout the years K-12. Who should be involved in making decisions—administrators, teachers, supervisors, consultants, and parents? Technological advances, new findings about the learning process, and new insights into behavior are continually suggesting new answers to these problems.

A second concern is provision of the kind of organization in which a school staff may work toward implementing decisions. Materials and resources, including the best specialists available for consultants, must be made available if teachers are to work competently with new concepts in their subject fields and new materials at the same time they are readjusting teaching methods to meet new demands. Time must be provided for examining and evaluating new findings and their relation to boys and girls during their years of study.

A third concern is maintaining an atmosphere marked by freedom to experiment with what should be offered both in an entire school program and in the specific program planned for each learner according to his aspirations and abilities. Selection of courses must be made individually for each student with his approval and that of his parents, under the guidance of school personnel. A balanced program exists only in terms of each learner.

Freedom to ask the right questions, and the resources and encouragement to work toward the best answers are the rights of each educator as he continually faces the problem of what should be taught, when, to whom, and by whom. Our appreciation goes to the science teachers for their experience in the early days of the new look at balance in the curriculum.

MARGARET GILL
Executive Secretary
Association for Supervision and Curriculum Development, NEA.

THE SCIENCE TEACHER

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Readers' Column

More on PSSC*

NOTE: The comments sent in by William Barish on the PSSC course and printed in the October issue of *TST* have initiated many responses from our readers. We have selected certain excerpts from these in order to avoid repetition of comments and to present to our readers the major viewpoints expressed by others. (The numbers in parentheses represent the items as listed in the Barish letter in *TST* of October.)

Readers are referred also to the comments from other individuals on page 579 of this issue. These are included in the current report of the PSSC project.

"Currently, I am teaching the PSSC physics for the second year to the college preparatory students at the senior high school. I take 'issue' with Mr. Barish's statement that the material is 'too difficult.' I feel his approach indicates a lack of background and experience with the course and some inconsistencies. His comment (4) on preparation of laboratory materials (ripple tanks, kits, etc.), is now outdated since most of these materials are available at low cost. This was not true in the beginning. There is much merit in using equipment less complicated to enable the student to complete an experiment independently and arrive at his own conclusions. I see no objection to the use of a trip balance or analytical balance for this purpose."

David Kutliroff
New Brunswick Senior High School
New Brunswick, New Jersey

"As a college teacher, I have been closely associated with over 700 teachers of high school physics through our Case-General Electric Science Fellowship program for high school teachers. From this experience the spirit of cooperation between the two groups has never made us feel high school teachers were 'not too bright' or that college teachers were superior to them. We have always been tremendously impressed with the sense of dedication and sound direction of their efforts.

"(4) PSSC is continuing to devote considerable effort to reduce the time required for teachers to set up their laboratory experiments. The open-end experiments of the PSSC, and especially the philosophy of PSSC, emphasize that the student should think about the experiments. This is commendable. If the simple but sensitive soda straw balance doesn't thrill the teacher, it won't thrill his students, and such a teacher should perhaps use the analytical balance.

"(5) Any physics course, or for that matter, any course of whatever kind, would produce the best results in an educational Utopia. The (a) through (d) prerequisites cited by Barish are not unique requirements for the PSSC course. Both high school and college teachers know the 'facts of life' about large and small high schools, and also know that these facts need to be changed if we are to improve education in this country. Finally, it seems to me that the imagination of the PSSC movement has developed much constructive thinking about physics teaching in the high schools. It has sparked similar thinking about college physics and other teaching areas. Certainly, no one associated with PSSC would believe that they have said the last word on any areas with which they have been working. Let us congratulate PSSC for their contribution to education improvement."

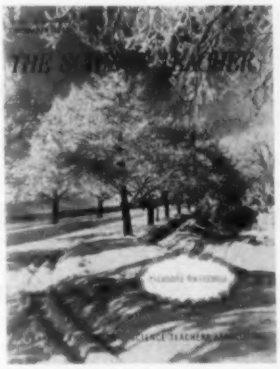
Leonard O. Olsen
Case Institute of Technology
Cleveland 6, Ohio

"As a teacher of the PSSC course at our high school in Connecticut, let me say that under (2) of the Barish letter, I contend that the PSSC course, more than any other course, keeps at the focal point the relation between the physical world and the fundamentals of physics as taught in the classroom. It is

(Continued on page 604)

* Physical Science Study Committee.

THIS MONTH'S COVER . . .



In areas where winter scenes capture the imagination, a stimulating activity for students is suggested—namely, the study of snow crystals. What factors influence shape of snow crystals? What is the relation between shapes of snow crystals and temperature or supersaturation? What are the general classifications of snow crystals and their frequency of occurrence? Name the snow crystal structures diagrammed below.

(1) (2) (3) (4)

(Answers on page 589)

REPORT ON TITLE III

NATIONAL DEFENSE EDUCATION ACT OF 1958

By HERBERT A. SMITH

Chief, Science, Mathematics and Foreign Language Section, U. S. Office of Education, Washington, D. C.

NOTE: Address given at the National Science Teachers Association meeting, July 1, 1959, at St. Louis, Missouri. (Dr. Smith, former NSTA President, 1958-59, is on leave from the University of Kansas, Lawrence.)

THE following is a brief report of the progress that has been made in implementing Title III of the National Defense Education Act. As you well know, the National Defense Education Act is a complex piece of legislation. The law provides for eight operating programs and relates to education, both public and private, from the kindergarten through the graduate school. Its passage certainly establishes an historic benchmark in educational legislation, perhaps comparable in its significance only to the two Morrill Acts and to the Smith-Hughes Act. The implementation of this far-reaching piece of legislation represents a monumental undertaking.

Specifically, aside from the progress report, I would like to discuss one of the problems which I see arising as a result of the equipment acquisition provisions.

As of November 2, 1959, 51 state and territorial plans were approved for Title III. Thus, it is possible to move in the direction of greater attention to program development and to render assistance to states to help them to get an effective program into operation.

A number of activities are under way in the U. S. Office of Education which may be of interest to you. An analysis of the state plans which have been approved is now under way. We hope that this analysis will be available in preliminary form within a short time. The analysis will reveal information related to a number of state plan program elements. The priorities established by the states, the qualifications of state supervisors, certain characteristics of the science, mathematics, and foreign language programs, and information about the standards established for acquisition of equipment and materials and for minor remodeling projects will be included. The planned expansion of supervisory and related services by states is also being analyzed. We feel that this analysis will be of general interest.

Our foreign language staff has moved forward rapidly in the production of some materials which we hope will be helpful to foreign language supervisors in terms of providing suggestions for materials and also for helping teachers introduce the new aural-oral method of instruction. Other publications will be forthcoming as the needs are established and as our time and resources will permit.

Program Reports

A series of eight regional conferences have been held with the state administrators of Title III and certain statistical and fiscal personnel in order to discuss fiscal, statistical, and narrative reporting forms in detail. Data from these forms will provide us with information as to how the money available was spent and provide clues as to what has been accomplished. Six regional conferences for state supervisory personnel with responsibilities under Title III have been held. From these, insights were gained into the problems which are confronting state supervisors. The conferences also provided opportunities to explore with state representatives the kind of services which they desire from the U. S. Office of Education. Within the limit of the available resources, consultative services on professional problems are available to the states when such services are requested and when such assistance would be of benefit to them. The provision of these services represents an attempt to render needed assistance so that the developments going forward under Title III will be converted into an effective educational program. It is clearly evident, however, that the major responsibility for carrying out the provisions of the Law and for achieving the intent of Congress under Title III has now shifted to the states.

As a result of NDEA, many serious problems confront all of us, and of course, many different problems will need to be examined. We as professional educators interested in science certainly suffer no shortage on this score. For illustrative purposes, it appears necessary to me to select one particular problem and to explore it in some detail on the basis of current activities.

Americans, so it seems, have a tendency to panaceaism. It is amazing to see the extent to which we are addicted to first one educational fad and then to another. Fortunately, teachers have usually shown a great deal more stability in their approach to classroom instruction than might have been anticipated had they listened to certain educational leaders, to the press, and also to certain captains of industry and the military. The periodic occurrence of fads seems to continue in spite of the general principle that the complex problems of education cannot be solved by the simple expedient of choosing this or that particular panacea as "the answer" to our needs. Faddism in education is practiced by entirely too many persons who ought to know better. A little historical perspective would show that the educational midden heap is full of the bleaching bones of panaceas which were once hailed as the salvation of education.

In this instance, I would particularly like to "zero in" on the tendency to find in film presentations the magic solution to a whole host of technical educational problems. This happens to be an area which reflects my own research interests. Thus, I feel that I know something of the values and the limitations which are associated with the classroom use of teaching films. This experience prompts me to view with some apprehension the tendencies which we see today to move films into a central role in classroom instruction. In spite of the value that films have in particular situations, I am still convinced that they must be regarded as supplementary devices which are peripheral to the main business of classroom instruction.

Let us examine why it is that films seem to find such favor in various quarters. For one thing,

there is a certain amount of glamour attached to the use of films. Films are still sufficiently new to education to have the advantage of novelty. In addition, there has been a very powerful campaign to promote the use of films by various vested interests. It would appear that some school administrators have frequently been oversold on the merits of films, especially when they are tied in with television. Some administrators have tended to view films as a means of accommodating larger classes and of offering certain courses when a shortage of qualified teachers exists. Again, because of this glamour value, considerable public relations material has been provided for the local school administration. The use of films has been considered "the proper thing to do" to demonstrate that the community has an up-and-coming school system.

In addition, even some professional associations have placed themselves in the position where it is difficult to use reasonable objectivity in considering the merits of classroom films. They, themselves, have mistakenly, I think, become involved in film production. Thus, they too, have gained a vested interest and are not able to view the problem with complete detachment.

There is indeed a strange inconsistency in this new development. Many of these associations represent scientists who have continually emphasized the significance of laboratory work as being an indispensable part of science instruction. Yet, at the same time, we find the same individuals endorsing a film approach to science instruction. If this does not result in the reduction of the study of science to a sedentary occupation, it certainly does not emphasize many instructional procedures deemed especially valuable in science instruction. A common criticism of science instruction has been that it is too often a read-about-talk-about study to the neglect of real laboratory experience. I cannot see that the present over-emphasis on films is likely to change this, except that instead of a "read-about" approach we now have a "see-about" situation being advocated.

Education is an interaction process between teacher and pupils and among pupils. Films and TV cannot provide the continuous adjustment and instant adaptation that a sensitive teacher makes constantly. Thus, it is my conviction that the teacher is the indispensable element in any classroom; that the teacher's role is, and will remain, central; and that the quality of instruction will invariably reflect the competence of the teacher. It is my further conviction that the film is merely one tool from a whole chest of tools available to the classroom teacher. The weight of research evidence supports this view. Until independent research demonstrates conclusively an opposite conclusion, I shall continue to believe that films and their ally, TV, cannot replace the teacher. I shall continue to believe that when these instruments turn out to be effectively used, they will be used to supplement classroom instruction by the teacher. Thus, I cannot believe that the film will prove to solve the administrator's problems created by unqualified teachers or will be a satisfactory solution for providing for the greatly increased numbers of students in science study.

Use of Funds

Why have I spoken on this problem? And, why have I spoken with some vigor about the matter? Briefly, it is because I hope that the purchases which are eventually approved by the various states under Title III will reflect balance, not only among the three fields represented under this portion of the Act, but balance within each field relative to the various categories of equipment and materials for which supporting funds are available. Such balance is very likely to be attained if the full range of professional judgment is allowed free play. The voices of classroom teachers and supervisors should be clearly heard on these matters, and teachers and supervisors should not be subjected to pressures originating in sales, political, or administrative offices.

Thus, I sincerely hope that a disproportionate amount of funds available will not be diverted to the purchase of films when there are critical shortages of such basic items as laboratory furniture, foreign language laboratories, teacher-demonstration desks, scientific equipment, models, recorders, and books. This is, of course, a decision that states and local communities must make. I want to make it very clear that I am not against the use of films in classrooms, but I believe they should be carefully and individually selected for very specific purposes. These purposes should be of such a nature that they are achieved more efficiently by the use of films than by other methods. Films do render a valuable contribution, in a supporting role, but they cannot be regarded as "the answer" to our problems in science education.

For your information on detailed progress under Title III, there follows an abstraction from

the preliminary report for the period ending June 30, 1959. This preliminary report on all phases of the Act was released in September by the U. S. Office of Education.

Preliminary Report
U. S. Office of Education
Department of Health, Education, and Welfare
Washington, D. C.

FINANCIAL ASSISTANCE FOR STRENGTHENING SCIENCE, MATHEMATICS, AND MODERN FOREIGN LANGUAGE INSTRUCTION

TITLE III. *This Title makes available allotments to State educational agencies* to strengthen instruction in science, mathematics, and modern foreign language in the elementary and secondary schools. It is recognized that in these areas, there are particular imbalances and weaknesses which, in the national interest, must be corrected speedily.

In an effort to meet these pressing needs, the Act under Title III authorizes three related programs: (a) grants to State educational agencies for projects of local educational agencies for the acquisition of laboratory or other special equipment in the areas of science, mathematics, or modern foreign language teaching, and for minor remodeling of laboratory or other space to be used for such equipment; (b) loans to non-profit, private elementary and secondary schools for the same type of projects; and (c) grants to State educational agencies for expansion or improvement of supervisory or related services in public elementary and secondary schools (and junior colleges if under State law they operate as an extension of the local secondary school) in the areas of science, mathematics, and modern foreign language instruction, and administration of the State plans.

The Act further provides that States or local school systems must match Federal funds on a dollar-for-dollar basis for equipment and materials; beginning with fiscal year 1960, the State must match Federal funds on the same basis for its supervisory program and for the administration of the State plan.

Very successful were the eight regional meetings devoted to Title III (see full report) held between representatives from the Office of Education and from all but one of the States and Territories having approved State plans. The purposes of these meetings were to interpret forms which had been developed cooperatively by State representatives and the Office of Education and which the States are to use in reporting to the U. S. Commissioner of Education progress under the State plans; to help the States in resolving their problems with reference to the completion of the forms; and to assist the States in administering their State plans.

Great significance is attached to the six regional meetings with State supervisory personnel in science, mathematics, and modern foreign language which were planned for the achievement of these purposes; the opening of mutually helpful channels for working relations between the U. S. Office of Education personnel and the State supervisors; the clarification and interpretation of the Law as needed; the provision of opportunities for State supervisors to explore common problems with Office personnel, and the determination of needed and/or desired services which the Office of Education can provide.

LABORATORY EQUIPMENT AND MATERIALS AND MINOR REMODELING

TITLE III. *As of June 30, 51 States and Territories had submitted plans* in which they have set forth (1) a satisfactory program under which Federal funds will be expended solely for projects approved by the State agencies for the acquisition of laboratory and other special equipment and instructional materials, suitable for use in providing education in science, mathematics, or modern foreign languages in public elementary or secondary schools, and for minor remodeling of laboratory or other space used for such materials or equipment; (2) principles for determining the priority of such projects in the States; (3) provisions for the establishment of State standards for laboratory and other special equipment acquired with Federal funds.

Forty-nine plans have been approved and payments are being made for the purchase of equipment and materials to improve teaching in areas of science, mathematics, and modern foreign language, and for minor remodeling to accommodate this equipment. In addition, it should be noted that appropriations under this Title remain available for one fiscal year beyond the fiscal year in which appropriated. The sum of $49,280,000 was available for these purposes in 1959 and $52,800,000 in 1960.

Considerable time necessarily had to be spent in getting the program under way. In many instances where the Federal dollars were matched by local dollars, rather than State dollars, further time had to be spent in explaining to local school officials and to local taxing bodies the purposes of the Act and the importance and advantages of local participation. Therefore, in certain cases, the impact of this Act will be felt for the first time in schools this fall.

Participating States in most instances have completed the first phase of their Title III programs which consisted chiefly of "tooling up" the administrative machinery for implementing the State programs as set forth in the projects which local educational agencies submitted to the State educational agencies for approval under the State plan. During this period, procedures were established for the guidance of local school systems in submitting projects; many States employed supervisory staff composed of experts in the three areas; State standards for equipment and materials have been developed;

conferences have been held with administrators of local school systems in which information was given concerning the purposes of the Act and the requirements for participation; many experts in the three areas were summoned into consultation and valuable assistance has been given to local school heads in the preparation of projects for equipment and materials.

An example of the early indirect results stemming out of the National Defense Education Act is to be found in a recently published *Purchase Guide* which has been developed under the leadership of the Council of Chief State School Officers, with the cooperating assistance of the Bureau of Standards, the Office of Education, and other professional groups. This Guide renders a service to purchasers of equipment and materials in the areas of science, mathematics, and foreign languages and may well be the forerunner of other such contributions, designed to strengthen effectiveness in operation of the Act.

The Guide contains helpful information concerning the purpose and use of various items of equipment listed in the fields of science, mathematics and modern foreign languages; a list of items of equipment and materials; also a part called "Guidelines", devoted to the use of equipment; in the case of modern foreign languages, a rather full treatment of new methods and materials; and finally, a bibliography of books and materials which can be drawn upon to strengthen programs in science, mathematics and modern foreign languages. No trade names appear; no manufacturers' names are listed. Prices are not given. The cost of the Guide is borne by several private sources. Forty-four thousand copies will be distributed free to local schools.

APPROPRIATIONS FOR SUPERVISORY SERVICES

TITLE III. *An appropriation in the amount of $1,350,000* during fiscal year 1959 was made for supervisory and related services and administration made necessary by the implementation at State level of Title III. Of this amount, $1,130,756 was actually paid to the participating States and Territories. For fiscal year 1960, $4 million has been appropriated for this purpose.

The Office of Education is currently analyzing the provisions of State plans on the following subjects: programs existing before the passage of the National Defense Education Act; objectives of programs; principles for determining qualifications of special supervisors; description of supervisory programs for the implementation of the State plan; description of programs and standards for equipment and materials; methods of reimbursing local agencies; and principles for determining priorities of local projects.

There is evidence to show that the splendid cooperation manifest between the Office of Education and the State departments of education also extends from State to local levels.

LOANS TO NON-PROFIT PRIVATE SCHOOLS

TITLE III. *For the purpose of extending the benefits of Title III to non-profit private elementary and secondary schools,* the Act further provides that the Commissioner of Education shall allot out of funds reserved for the purpose, to each State for loans to non-profit private schools, an amount which bears the same ratio of such funds as the number of persons in such State, enrolled in private non-profit elementary and secondary schools, bears to the total of such numbers for all States.

Each participating school must satisfy the Commissioner that it will be able to repay its loan within a ten-year period. The interest rate set for the loan is determined by the Commissioner, who uses information furnished by the Treasury Department, in accordance with the provisions of the Act.

An interesting analysis of the purposes for which these private schools will use loan funds made available during the fiscal year 1959, reveals that 69 percent plan to up-grade generally the instructional program in mathematics, science, and foreign languages; 30 percent will offer courses for the first time in one or more of these areas; 21 percent will equip new construction; 21 percent will provide for increased enrollment; 18 percent will provide additional laboratory space; 12 percent will install foreign language laboratories; 10 percent will inaugurate new programs for exceptional children; 5 percent will provide more laboratory space; 5 percent will provide more demonstration teaching, and 4 percent will meet accrediting standards. (Some schools are included in more than one category to account for a total of over 100 percent.)

Applications from 88 of these schools have been approved in the amount of $1,104,919. The average loan for these 88 schools was $12,556; the median $6,000. Thirty-two States were represented in the loan program. States with three or more approved applications follow:

Ohio	16
New York	10
Illinois	6
Missouri	6
Kansas	5
Massachusetts	3
Nebraska	3
New Jersey	3
Oregon	3
Wisconsin	3

Eight States had two each; and fourteen, one. Loans varied from less than $1,000 to $245,000 in individual schools.

The Office of Education through its Annual Report to Congress, and other official reports and news releases will provide current information on this program as it develops and as more experience is gained in the administraton of the project.

It's always "Exam Time" ....for science teachers

Every science teacher must maintain a constant vigil over the perfect balance of budget, technique and curriculum. Examination of newer techniques; examination of possible curriculum changes; examination of available budget for materials and supplies . . . yes, it's always "exam time" for science teachers!

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Student Assistants—L

THE USE OF STUDENT laboratory assistants is fundamental to an effective laboratory program where the demands on the teacher's time and the limitations of facilities make each minute of laboratory time precious. At the same time that the student learns the pleasure of service and gives his help to the group, he feels the reward of importance and learns to improve his understanding of the field.

The securing of qualified and interested assistants has to be a cooperative arrangement between the teacher concerned and the school administration. Early in the spring the teacher should select a small number of potential candidates from his regular classes and assign them special project tasks to be performed during their lunch periods or after school. This serves the twofold purpose of determining not only their capability of carrying out assignments beyond the difficulty of the classroom, but tests their dependability and willingness to give extra time to the laboratory.

When the field has been narrowed to those who meet the qualifications fully, the needed number should be chosen on the basis of academic performance in the subject as well as the student's ability in his other subjects. The students chosen are requested to bring written permission from their parents approving their selection. Then the school administration, through the guidance department, is requested to arrange schedules for these students so that they are assigned to the teacher at designated periods.

During the year 1957-58, two student assistants were appointed for the chemistry laboratory, one for each section the teacher taught. Chemistry is not offered in our school until the junior year. Therefore, these students were seniors during this year. We operate on a seven-period day with one of these periods serving as a lunch time. Thus, a senior, who has made regular academic progress, would need four or fewer academic credits which could be secured in four periods. This meant that each of the boys had a period available during which he could be assigned for his laboratory job. Further, since the time of the classes was coincident with the lunch periods, the administration was able to schedule the boys for lunch just prior to their laboratory assignment. This meant that in special situations they could be available for longer periods of time.

Since the program was new in our school this year, we wanted to build a favorable climate for its success. This was initiated by having both boys come to the school when the teachers reported for their pre-school conferences. At that time the teacher and the boys discussed the anticipated work and the routine to be followed in carrying out the assignments. Together they placed the laboratory facilities in order and agreed on procedures for the handling and storage of supplies and equipment.

To demonstrate the importance of the work of these assistants to the school, the principal made a special fund available to the teacher to purchase white laboratory coats for their use. It is surprising how important these coats were to the boys. They wore them with pride.

At the beginning of the term each of the boys was introduced to his class and his role as assistant was explained. Since we do not have a set time for laboratory work, we thought it was important for our laboratory assistants to attend all class sessions. In this manner their performance in the laboratory would be more valuable. Also, they could be helpful in the ordinary class procedure by helping with such routine matters as checking attendance, clearing chalkboards, running errands, setting up and returning demonstration materials to the stockroom, and other tasks. Occasionally, they could even assist in checking routine homework or helping in the

Laboratory assistants: Richard Parr, David Dorward. Students: B. Harris (author observing) and R. Von Sharpe (left to right). Photo by Dan Wheeles, student photographer.

LABORATORY INDISPENSABLES

By MORRIS S. TISCHLER

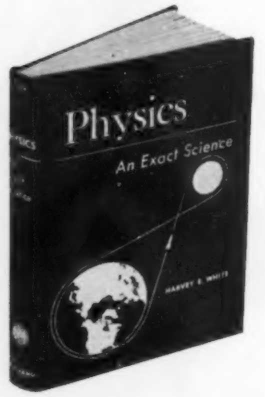
Science Teacher, Fairfax High School, Fairfax, Virginia

teaching procedure such as that involved in learning to use a slide rule.

To operate our laboratory at maximum efficiency in relation to equipment and space available, we have tried to have twelve experiment stations (our class size did not exceed 24) with two students to each place. In order to get the most efficient use of time, the assistants make ready all materials and equipment in appropriate areas. To keep order also in the storage of items, they return everything to the storeroom after the students clean and bring all to a central area. Another valuable aid rendered by these assistants has been in opening the laboratory for students engaged in special projects such as assembly programs, individual project work, and making up assignments.

Some pleasant responses have helped make the program more successful. One of these has been the positive attitudes of the parents of the assistants in regarding these appointments as signs of high honor. The other teachers in the school have helped by complimenting the boys on jobs well done. The school newspaper has featured the work as important by publishing articles and pictures of the boys at work. The most gratifying compliments, however, have come from students enrolled in the course. They have shown their appreciation by requesting information from their assistant, and there has been no evidence of their reluctance to accept good advice. The highest praise is evidenced by open competition among several accomplished students for these positions of service and honor for the coming year.

The center of attention



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Evaluation of Experiments In High School Science

By ARTHUR C. MURDOCK

Science Instructor, Sutton High School, Sutton, Massachusetts

SCIENCE instructors who enjoy their work are continually revising experiments and trying new ones or new approaches in an attempt to interest the students and provide a thorough course of instruction. Most educators agree that the basic worth of laboratory instruction is an integral part of a good science course. Hence, we must improve methods of instruction.

The purposes of this article are to discuss some qualities of a good laboratory experiment and to suggest a quantitative method for evaluating various experiments so that the science instructor can better understand the strong and weak points of his particular series of laboratory exercises. When these strengths and weaknesses are known, the instructor can take steps to improve on the weaker areas.

The first job in the evaluation is to agree on the requirements for a good laboratory exercise, and decide exactly what we are trying to do in the laboratory phase of our courses. Richardson maintains that the science laboratory should: (1) provide a source of problems for the students to solve, (2) provide for the solution of problems, (3) promote understanding of the scientist's role, (4) provide illustrations of phenomena, (5) teach principles and concepts, and (6) contribute development of skills, habits, and attitudes.[1]

Stollberg sets up the aims of the laboratory exercise in the following manner: (1) to increase critical thinking, (2) to increase powers of ob-

[1] John S. Richardson. *Science Teaching in Secondary Schools.* Prentice-Hall Inc., Englewood Cliffs, New Jersey. 1957. p. 70-3.

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servation, (3) to develop keenness of initiative, (4) to gain deeper insight, (5) to acquire improved understanding of basic concepts, (6) to increase proficiency in useful skills, and (7) to develop interest and curiosity.[2]

From these two examples of aims of the laboratory experience, it is obvious that the proponents of the laboratory as a teaching method have high hopes for its success. It must be noted that merely having the laboratory part of the course included in the curriculum does not insure that the desired aims will be met. Every teacher should have some plan for the constant evaluation and improvement of the laboratory work that is performed.

Planning Experiments

A general criticism of the laboratory centers on the stereotyped exercises found in many laboratory manuals. The students follow very detailed instructions and merely fill in answers as they go along. There is little or no room for the student to use his own initiative or reasoning. In order to finish the experiment he may often get the answers to the blank spaces from his neighbor. Watson illustrates the feeling of disgust that is common when he says, "The actualities of scientific investigation are not going to become significant to pupils through the canting of incantations or filling in of any five-step laboratory report forms."[3] From the tenor of the literature it appears that the trend is away from this stereotyped method of teaching.

Today most educators agree that the laboratory phase of science instruction does have a place in the program. There may be differing views on where the emphasis should be placed, i.e., which students should be given this type of instruction, how much time should be allotted, and when; but few educators would suggest that the laboratory experience be eliminated. Most of us feel that a science course without a laboratory phase is not worthy of the name science. The very nature of science explains this devotion to the laboratory. Interwoven in the history of science is the experiment, so it is only natural that the opportunity for experiment be part of the process of learning a science. If a person is to understand fully and continue in science, he must

[2] Robert Stollberg. "Learning in the Laboratory." *The Bulletin of the National Association of Secondary-School Principals*, 34:102-3. January 1953.

[3] Fletcher G. Watson. "The Place of Experiment in Science Education." *The Bulletin of the National Association of Secondary-School Principals*, 37:100. January 1953.

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Students and teacher evaluate the various experiments used in the laboratory. (Caroline County High School, Va.)

be familiar with the methods and techniques of the scientific laboratory. You cannot effectively teach a mechanic by books alone; by the same token, a scientist must be able to manipulate his hands as well as his mind.

Davis lists five types of laboratory activity for high school science courses: (1) getting information, (2) providing solutions to problems, (3) controlled experiments, (4) verification of items presented, and (5) projects.[4] Each one of these general experiments allows the individual the opportunity to work independently, to feel things, to weigh them, to smell them, to compare them, and to use or build apparatus. These are some of the reasons why the laboratory exercise can be important as a learning device. The pupil is not passive in the learning role; he is an active participant in an ever-expanding search for answers to questions.

What, then, are the qualities of a laboratory experiment which make it valuable as a learning experience? Stollberg mentions these important characteristics:

1. The work must be closely integrated with the course.
2. The laboratory schedule must be flexible.
3. Seeking answers and finding information is important.
4. Real problems must be chosen if possible.
5. Practical applications should be stressed.
6. Cooperative planning by pupils and the teacher is highly desirable.
7. Laboratory manuals should be used merely for reference.
8. The laboratory should be thought of as an approach, not merely a place.
9. Some of the experiments should be of a long-term nature.
10. The note taking and recording of data should be truly functional.
11. Required reports should be meaningful.[5]

Selection of Problems

The paramount characteristic of a good science laboratory experience is its integration with the regular class work. For optimum results, it is essential that the student not become confused with a discussion of one principle while he is in the process of conducting experiments in another.

The bulk of the laboratory work should be centered around seeking answers to problems and finding information that is desired. If possible, these answers should be answers to questions that are real problems, preferably ones to which the student wants to find the answer. All laboratory experiments cannot be of this nature, yet many could and should be of this type. No one will deny that a student will work more efficiently if he wants to know an answer to a question, than if he were told he should know the answer.

Flexibility of schedule insures that when interest has been developed in an area, work may be done in the laboratory at once, instead of waiting for a particular time on a certain day of the week. Human nature is such that there is a right time for work to be done. To wait may well mean to lose enthusiasm that was generated for a specific learning situation.

The laboratory instruction must be set up to seek answers and solve problems as Stollberg pointed out, but the important issue that goes along with this suggestion is that the problems are better if they are of a practical nature and are ones which the students themselves want to solve. This is where cooperation of pupil and teacher is involved. The teacher must be able to direct the class in such a manner that significant problems are chosen for the laboratory work. At the same time, these problems must be practical, and be desired by the students. This may

[4] Ira C. Davis. "A Plan for Laboratory Activities in General Science." *School Science and Mathematics*, 47:146-7. February 1947.

[5] Robert Stollberg. *Op. cit.*, p. 104-7.

seem like an insurmountable problem, and admittedly all problems cannot be of this type, yet many can and should be so developed.

One of the highly desirable results of a laboratory experience can be the development of skills in the realm of apparatus design and building. The Physical Science Study Committee working at the Massachusetts Institute of Technology has done a great deal with this in the area of physics. Whenever the choice exists between buying or making the equipment with a reasonable effort, it would seem that the latter should always be chosen. In some cases this is not feasible; but in many cases it is to be recommended as pupils must exercise judgment, manual skill, dexterity, ingenuity, and resourcefulness. This makes for better student performance.

Stollberg suggests the use of several laboratory manuals for reference.[6] This does not imply that the manuals should be used to replace creative planning, but merely to aid in this more desirable process.

Some of the experiments definitely should be carried on for some time so that the student may realize the value of experiments. Naturally, a student must do many simple, short experiments, but these should be augmented by those that evolve day after day, or for several weeks or months. Continued experiments help to develop a greater appreciation for the routine data taking and teach students that success and/or failure is a part of this process.

In reference to Stollberg's last two characteristics on recording and reporting, let it be said that science instruction should have little so-called "busy work" included. There is sufficient subject material for the limited time to work and there is no excuse for the instructor giving assignments without some definite purpose. Lefler suggests that the instructor feature one part or discipline of a report each lesson, rather than have the student go through the entire laborious process of a full report repeatedly.[7]

If all or most of the preceding ideas have merit, the problem now arises of finding some fairly comprehensive, yet convenient, method of evaluating the relative merits of individual experiments. The method suggested here for an appraisal of laboratory work is a check list that asks the instructor to make judgments on various characteristics of a proposed experiment. Each question has been worded so that a "yes" answer implies a superior quality; the total number of "yes" answers on each experiment may be called the score.

There is, of course, no absolute score involved in this method of appraisal whereby an experiment passes or fails. It is doubtful that any one experiment will measure up to all of the criteria. The check list has the added feature of pointing out to the instructor the particular areas of an experiment that are weak. These areas might be strengthened by a change of emphasis.

Ideally the instructor would duplicate or mimeograph the check list and eventually build up a complete evaluation file of all the pertinent experiments available. The individual evaluation file might also reveal that many of the experiments show a consistent weakness in specific areas. It is hoped that this would suggest to the alert instructor those areas where he might best seek to improve the quality of his instruction. It is not enough to leave evaluation to subjective methods; there must be some quantitative way of going about it.

Individual Experiment Evaluation Check List

	YES	NO
Has there been sufficient preparation for the experiment?		
Is the note taking, data recording, or sketching, truly functional?		
Does the experiment:		
Utilize the scientific method?		
Develop critical thinking?		
Involve improvisation or ingenuity?		
Cultivate good laboratory habits?		
Reveal new concepts?		
Reveal new facts?		
Teach new skills?		
Develop the power of observation?		
Indicate practical applications?		
Involve cooperative planning?		
Give insight into the role of science?		
Have historical value?		
Is the experiment:		
Integrated with the course?		
Quantitative?		
Such that each individual has unique but related results?		
Pupil initiated?		
Are the required reports meaningful?		
Will there be sufficient follow-up?		
Totals		

[6] Robert Stollberg. *Op. cit.*, p. 106.

[7] R. W. Lefler. "The Teaching of Laboratory Work in High School Physics." *School Science and Mathematics*, 47:537. June 1947.

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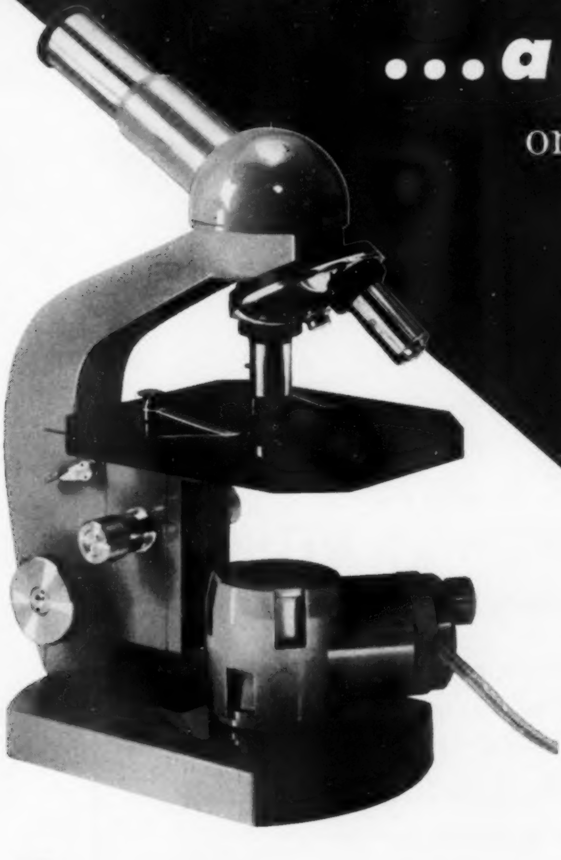

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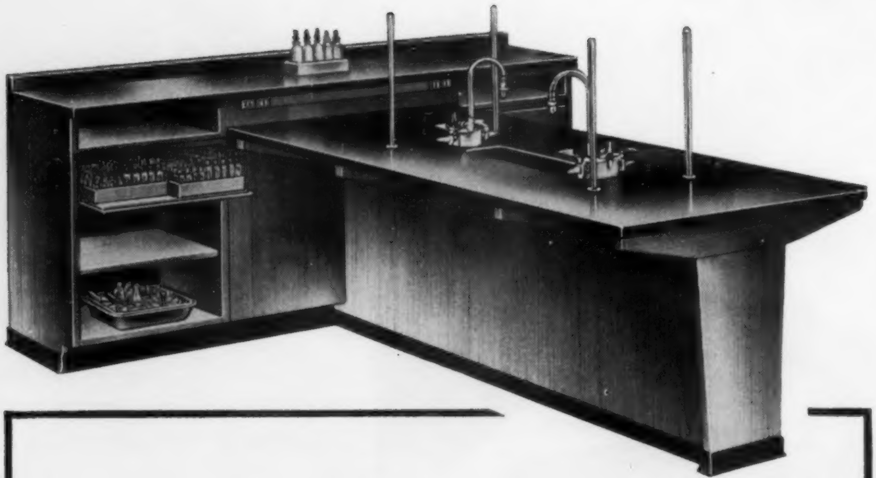

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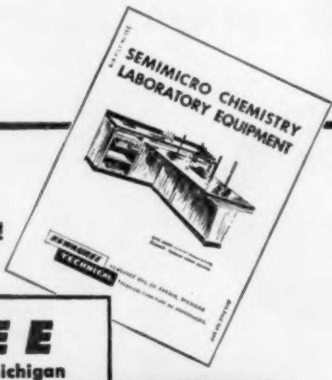

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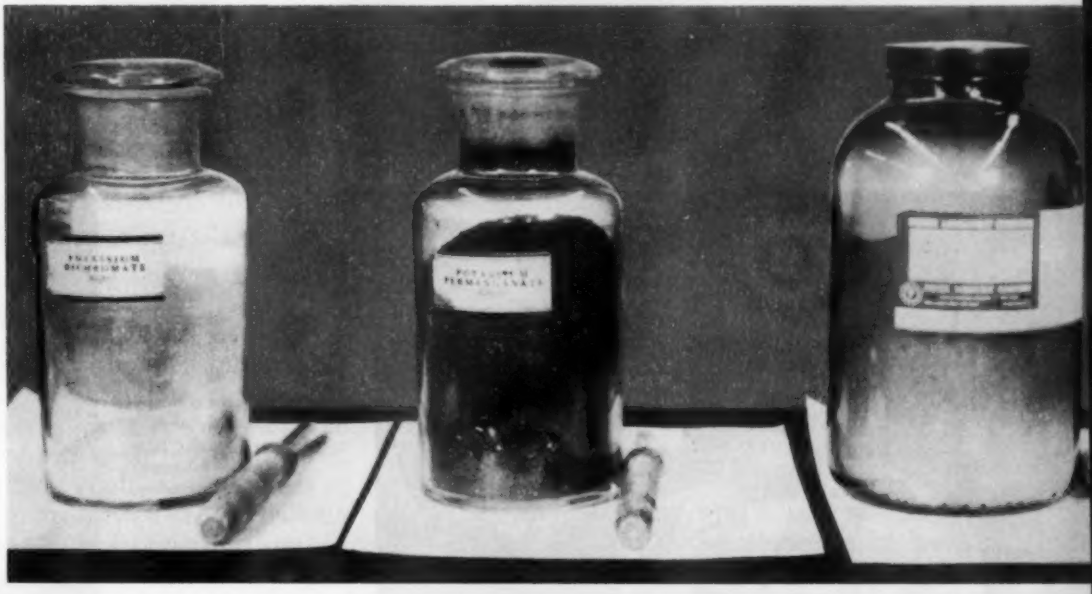


Here is the way salt stock bottles should always look—stoppers in and no residue on the shelf.

OR FIRST AID ?

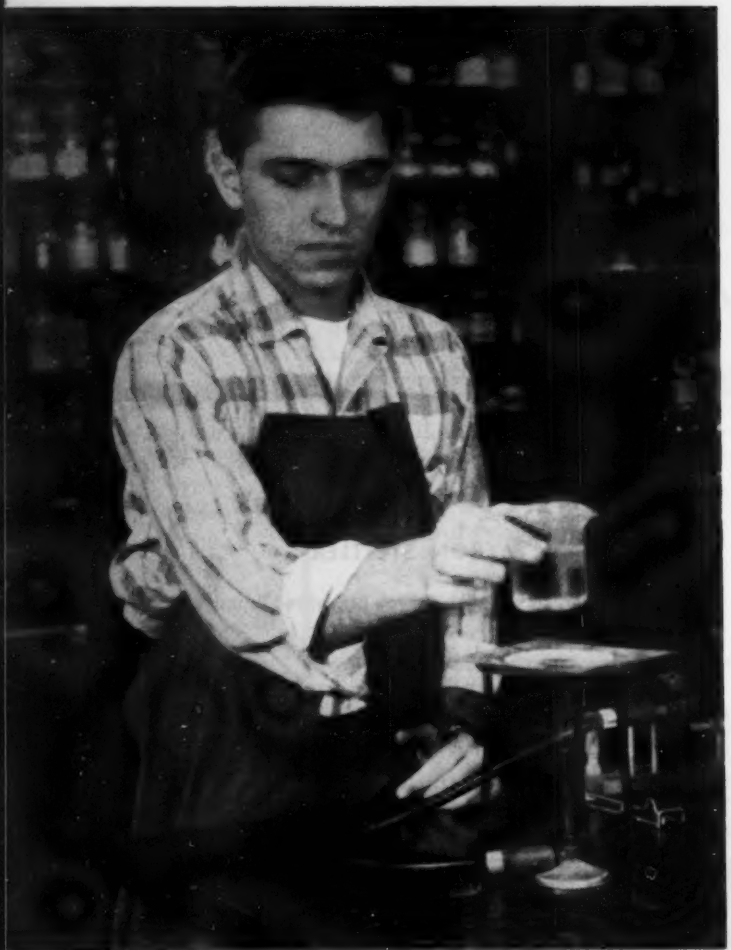
By MYRON STETTLER

Chemistry Teacher, Liberty High School, Bethlehem, Pennsylvania

A CHEMISTRY laboratory is one place where students quickly learn that work habits are consistently right, or dangerously wrong. You aren't half-right when the thistle tube you have been trying to force through a stopper suddenly breaks in your hand. And you aren't half-right if the reagent stopper carelessly left on the working desk becomes contaminated by contact with other chemicals.

Mr. Stettler's STAR entry included a study, together with a pictorial story illustrating proper laboratory techniques. Space limitations prevent publication of the entire article, but the display presented describes in part the methods he utilized in developing the preliminary unit in high school chemistry, "Essential Foundations of

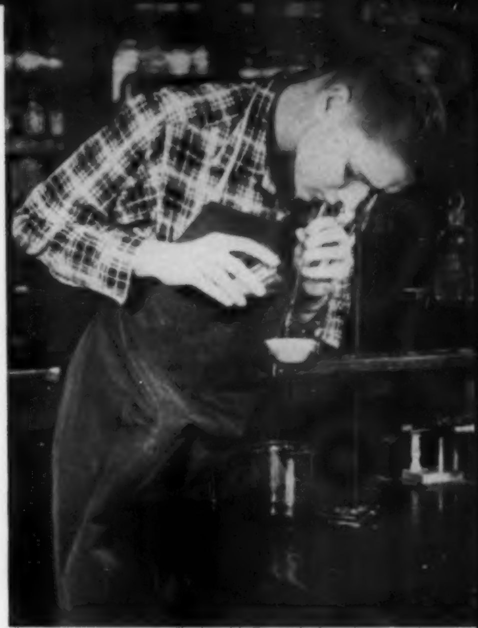
Use your hands to hold reagent stoppers properly. Placing covers on the desk leads to contamination.



Crucible tongs should not be employed in removing a hot beaker from a ring stand. A pad in your hand forestalls burned fingers.

Never force a thistle tube through a stopper. Water is a good lubricant in this instance.

Two correct practices for accurate calculations: the young lady is using her forceps to handle the weights, and she is preventing "jarring" of the pan by steadying it with her hand.



Careful and complete filtering is achieved when the funnel stem is within the beaker receiving the filtrate.

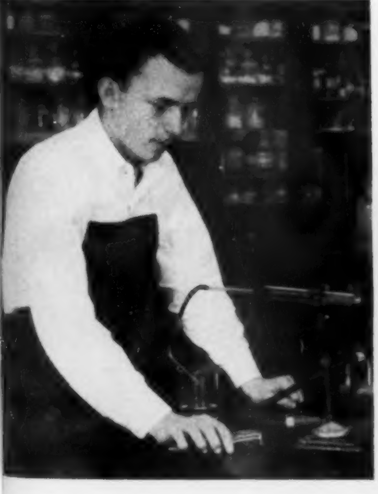
Careless and incomplete filtering is predicted when the funnel stem is far above the beaker receiving the filtrate.

Good Laboratory Practices." Over a period of years, he has observed that students will follow certain procedures or work habits more often than others. From these observations, the author has utilized the material submitted in his entry. One of the most effective parts of the unit is the demonstration of incorrect *vs* correct procedures. As a follow up, situation photographs, similar to those presented here, are posted on the bulletin board. The result has been spontaneous student interest and correction of bad laboratory procedures throughout the year.

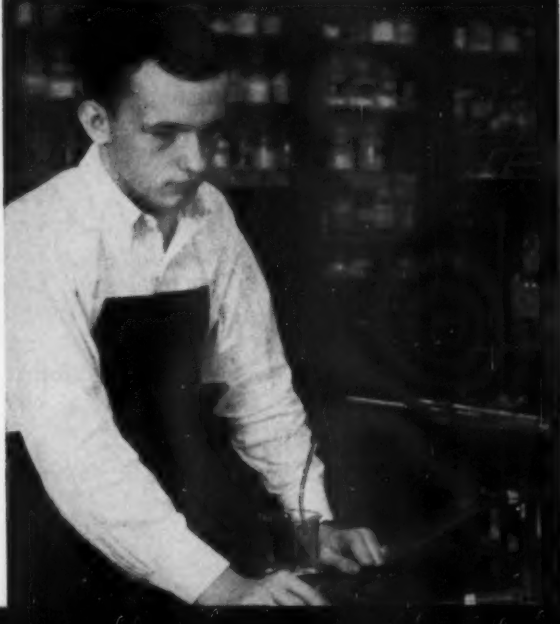
Slovenly habits and experimentation can produce at its best, below average experimentalists. Observations in commercial laboratories have shown time and time again that the careless technician, the routine chemist or research helper with poor work habits will find it extremely difficult to climb the ladder of success in the chemical industry.

The responsibility of the chemistry teacher in the high school laboratory with relatively "green" material is a tremendous one. Since safety and proper laboratory techniques go together as does Bunsen and burner, the methods employed, to insist upon and at the same time encourage safety and good laboratory habits, are very important.

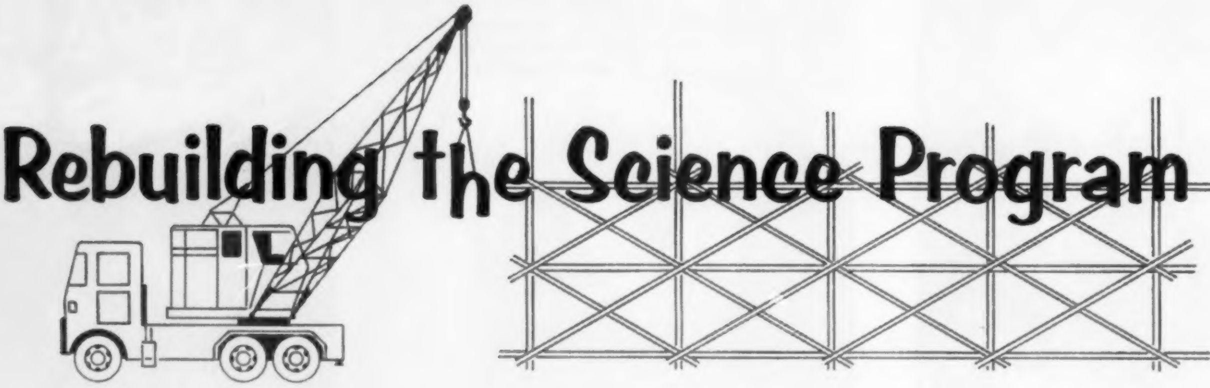
Readers who may be interested in writing the author relative to his complete study are invited to do so.



This young man is committing two frequently exhibited laboratory errors. Note the high flame and the low placement of the test tube clamp.



A controlled flame and proper clamp placement insure correct heating of the materials in this test tube.



Biology

Need For More "Bios" in Biology

By PHILLIP R. FORDYCE

Biology Teacher, Oak Park and River Forest High School, Oak Park, Illinois

IN the field of biology the study of plant physiology ideally provides a student the opportunity of investigation and discovery within the confines of the laboratory period. Certainly other areas of biology also offer such experimental opportunities. Often these other areas do not lend themselves too well to the rigid time schedules in which the student and teacher must work, or they require equipment or apparatus often lacking in the high school biology laboratory. Not only does the study of plant physiology lend itself well to the above limitations, but it provides the opportunity to "bring alive" the botanical area of biology which is all too often regarded as dead or disinteresting by many high school students.

Biology courses across the country vary considerably in approach and point of emphasis. Despite this apparent lack of uniformity it is felt that all courses include a study of photosynthesis and respiration. It is on these two fundamental concepts that the following exercises are based. The exercises described are not new, unique, or costly. Perhaps it is their relative simplicity which enables the student to obtain clearly a meaningful understanding of these processes and experimental methodology.

Photosynthesis

Problem: To demonstrate that plant leaves make food, but that this process requires light, carbon dioxide, green tissue, and water.

Materials: Acetone or 95 per cent alcohol.
Coleus or Geranium plants.
4 twenty-five ml beakers or small bottles.
4 one-pint canning jars with jar rubbers and lids.
Sodium bicarbonate.
Iodine—Potassium Iodide solution.
Sodium hydroxide.
4 Petri dishes or saucers.

The plants used should be held in the dark for two or three days prior to the experiment. One of the plants should have green-white variegated leaves.

Procedure: Remove four healthy leaves from the test plant: Place the petioles of each in the four small beakers or bottles of water. Set each bottle, with the leaf, down into one of the pint jars. The leaf blade should not be shaded. Without touching the leaves pour the reagent in the bottom of the pint jars. Arrange the four jars in the following way:

1. The reagent in this jar should be a one-

half inch deep layer of 5 per cent sodium bicarbonate to serve as a source of CO_2; the leaf should be green; strong natural light should be provided; seal the jar.

2. The same set-up as in (1), but use a variegated leaf.
3. The same set-up as in (1), only the jar should be placed in the dark.
4. Leaf should be green; the reagent should be 10 per cent sodium hydroxide to remove CO_2 from the air; light should be provided.

The jars in the bright natural light may yield positive results in two hours; however leaving them overnight with artificial illumination will assure better results. At the end of this time remove each leaf from its sealed jar and tag it to prevent a possible mix-up. Kill the tagged leaves by placing them in boiling water until limp. Transfer the tagged leaves to a warm or hot alcohol solution which will remove the chlorophyl. Place the blanched leaves in separate Petri dishes and cover each with the iodine solution for five minutes. A black coloration of a leaf indicates that starch has been formed.

Results: Jar (1) leaf, where all supposed requirements for photosynthesis were met, shows the presence of starch as an evidence of food production and storage.

Jar (2) leaf, shows only starch formation in the formerly green areas of the variegated leaf.

Jar (3) leaf, with light missing, gives a negative starch test indicating no photosynthetic activity.

Jar (4) leaf, lacking CO_2, also gives a negative starch test.

A fifth jar, the check on the necessity of water for photosynthesis, may be set up as in (1) except that the small bottle containing the leaf should be empty. This may produce tricky results for the student to ponder, if the test runs within two hours.

Superficially this compound experiment seems to substantiate the needs of certain raw materials for photosynthesis. For the average or below-average student this can be a fit stopping place, but for the able student it should only be the beginning. The able student should be challenged to locate unchecked variables or possible sources of error in this exercise. The able student should also be caused to validate the given tests or supposedly true statements made in the exercise. It is then, in the process of this search for knowledge, that the thrill of investigation is captured. To the author, herein lies the real value of the laboratory. Once a student has captured the "research spirit"—the validation of principles by experimentation — an important but secondary objective comes easily.

Respiration

Problem: To demonstrate that plants as well as other living organisms produce carbon dioxide.

Materials: 1 per cent barium hydroxide.
Germinating seeds.
Green leaves.
2 small bottles or 25-ml beakers.
4 one-pint screw-top canning jars with lids.
Pea gravel or other inert inorganic material which is not carbonate.

Procedure: Set up the four pint jars as follows:

To jar (1) add moist germinating seeds to a depth of one-half inch. Seal and place jar in the light.

To jar (2) add an amount of moist pea gravel or other inert inorganic material to a depth of one-half inch. Seal jar and place in the light beside jar (1).

In jar (3) place the petiole of a freshly removed green leaf in water in the small bottle or beaker and set the bottle and leaf into the pint jar. Seal the jar and place it in the light.

For jar (4) repeat the arrangement of jar (3), but place this jar in the dark. After 24 hours pour 10 ml of $Ba(OH)_2$ into each jar and reseal. This should be done as quickly as possible to prevent undue gas loss from any jar. Rock the jars gently and then tip to observe the cloudiness and precipitate in the added reagent.

Results: A carbonate precipitate should be abundant in jars (1) and (4) where respiration is the dominant process. In jar (3) where photosynthesis has removed the CO_2 and in jar (2) which contained non-living matter no precipitate or cloudiness will be observed.

Problem: To demonstrate the utilization of oxygen during respiration. A fairly simple method is a manometric one which will require a supply of mercury and a general knowledge of the composition of the air.

Materials: 1 large-mouth bottle.

1 single-hole rubber stopper to fit the large-mouth bottle.

1 J-shaped glass tube, the long arm of which should exceed 8 inches, with the cross-arm approximately 4 inches long and the short vertical arm about 3 inches in length. (With the J-tube in an inverted position the short vertical arm should be inserted through the one-hole stopper.)

1 small bottle, 10-ml beaker or vial.

1—250-ml beaker.

Germinating seeds.

10 percent sodium hydroxide solution.

A supply of mercury.

Procedure: Add germinating seeds to the wide-mouth bottle to a depth of one-half inch. Carefully insert a small vial, bottle, or beaker half full of 10 per cent NaOH into the wide-mouth bottle. (A small noose of string facilitates the lowering of the vial into the bottle without a spilling mishap. Contamination of the germinating seeds with the reagent will invalidate the experiment.) A cylinder of filter paper dipped into the NaOH and extending above the mouth of the vial or beaker will speed the absorption of carbon dioxide. Insert the stopper tightly into the wide-mouth bottle and arrange so the long vertical arm of the J-tube dips into the mercury held in the 250-ml beaker.

Results: As respiration proceeds, the oxygen is used by the seeds and the carbon dioxide is absorbed by the NaOH resulting in a rise of the mercury in the glass tube. The maximum rise is equivalent to the partial pressure of oxygen in the air, or 20 per cent of the prevailing atmospheric pressure.

To conserve space only a brief mention will be made of some interesting, truly experimental, and relatively inexpensive investigations possible in plant physiology.

Seed Physiology

1. Seed production determination by isolating certain plants in polyethylene tents and making counts. Postulate on rate of fecundity—over production as a natural phenomena.
2. A. Comparison of dormancy periods in plants. Attempt to ascertain why certain plants show marked variation in dormancy time.

   B. Break dormancy artificially.
3. Vary the germination factors of O_2, H_2O, and temperature for given seeds. Try to determine optimum and minimal requirements for germination.

Growth Physiology

1. Measurement of force exerted by plants by setting vertical one-half inch diameter tubing around emerging epicotyl and suspending vial with lead shot within tube just touching epicotyl. Have 10-20 such set-ups each with a different amount of shot in the vial.
2. Demonstrate mass law of growth by cutting tubers into cubes of varying sizes with each cube containing only one eye, planting and charting early growth. The same may be demonstrated by removing various fractions of endosperm or cotyledon.
3. Determination of weight gain or weight loss from original seed weight by etiolating one set of plants, growing one set of plants in the light, and not planting a third set of seeds. Obtain fresh weight of each set, dry in 150°F oven and obtain dry weight of each set. Compare per cent gain or loss and account for it.

Related Studies

Other valuable experimental and relatively inexpensive investigations which may be of use in plant physiology include those experiments related to the study of digestion physiology, plant reactions from toxic materials, and many others. It is not possible to give more detail in this article. Although the listing does not describe all or even the major areas of plant physiology, the studies provide valuable learning experiences for the student. Important topics such as nutrition, conduction, translocation, and auzin influence, which were not mentioned, also have in them a wealth of opportunity and experimental challenge for the able student.

Teachers who have approached the botanical area of biology through the traditional study of plant taxonomy and morphology may be pleasantly surprised to find that as the student begins to recognize the relationship between structure and function his appreciation for both increases.

Rebuilding the Science Program

Chemistry

What Every Young Chemist Should Know

By EDWARD C. FULLER

Chairman, Department of Chemistry, Beloit College, Wisconsin

MAN'S knowledge of chemistry is now so vast that selecting what to teach the beginning student is a problem of primary importance. One way of solving this problem is to build the first course around a framework of basic principles which will enable the student to understand many different kinds of chemical changes. These basic principles can be incorporated into the framework in different sequences and by different methods, but by the end of the beginning course the framework should include the concepts summarized in the following paragraphs.

All matter is composed of about a hundred elements. All elements are composed of very tiny particles called atoms. The atoms of a given element have a definite and known weight. This weight is so small that it is more convenient to compare the weight of a large number of atoms of the given element with the weight of an equal number of atoms of some reference element. The reference element is oxygen and the reference weight of oxygen is 16 grams which contain 6.02×10^{23} atoms of oxygen. The atomic weight of an element expressed in grams, is, therefore, the weight of 6.02×10^{23} atoms of that element. Because compounds are formed by the union of definite numbers of atoms of definite weight, the composition of a given compound is definitely fixed and definite ratios are found between weights of reactants and weights of products in a given chemical reaction.

All atoms are composed of three fundamental kinds of particles: electrons, protons, and neutrons. Each electron has one unit of negative electric charge and each proton has a charge of equal magnitude but of opposite sign; neutrons have no charge. A proton and a neutron have approximately equal mass but the mass of an electron is only about 1/1837 as great. The protons and neutrons in an atom are jammed together to form a very tiny nucleus at the center of the atom. The electrons "fill up" the rest of the space occupied by an atom by flying at enormous velocities through this space. Different electrons possess different amounts of energy as they fly around the nucleus. An electron may absorb energy and move into a flight path (called an "orbital") of greater energy or give up energy and move into an orbital of lesser energy. Different forms of energy may be absorbed by electrons when they rise to higher energy levels but the reverse process produces electromagnetic radiation, usually in the form of visible or ultra violet light or X rays.

Orbital Address

The spectra of an element can be analyzed to determine what energy levels are occupied by electrons and what energies are involved in shifting these electrons to higher or lower levels. Energy levels are described in terms of four quantum numbers which give the "orbital address" of an electron in the atom. Only one electron can have a given "address" (set of four quantum numbers). There are well defined limits to the numbers of electrons which can occupy a given main or sublevel.

When an element is used as the target anode in an X-ray tube, a spectrum with a fairly simple

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pattern of lines is obtained. When the X-ray spectra of all the elements are compared, it is found that this characteristic pattern shifts toward shorter wave lengths as one proceeds from elements of low atomic weight to those having heavier atoms. If the elements are arranged in a list so that the one at the top of the list has the pattern at the highest wave length, the second has the pattern at the next highest wave length, etc., with the element having the pattern at the shortest wave length placed at the bottom of the list, some striking facts are observed. First, it appears that the number of the element in the list is also the number of electrons which are needed to account for the visible and ultraviolet spectra of the element. This "atomic number" of an element is more important than its atomic weight when we try to relate the characteristics of an atom to the properties of the element in chemical reactions. A second striking fact which emerges from the numerical list is that certain patterns in the "addresses" of the electrons recur at regular intervals. We find that Helium has 2 and each of the other gases which are chemically inert has 8 electrons in the outermost main energy level and that all the inner levels are filled to capacity with electrons. If we now make a tabulation of the elements with the inert elements placed in the right-hand column with the lightest at the top and the heaviest at the bottom, we find that a Periodic Table of the Elements can be constructed with "groups" of elements of quite similar properties in vertical columns and "periods" of elements with gradual changes in properties in horizontal rows. The nonmetallic elements are found to be clustered toward the right-hand and upper portions of the table with the most reactive nonmetallic elements in the upper right-hand corner (excluding the column of chemically inert elements). The most reactive metallic element is found in the lower left-hand corner. In a given vertical group, nonmetallic properties increase and metallic properties decrease as one goes upward. In a given horizontal period, nonmetallic properties increase and metallic properties decrease as one goes from left to right.

Crystals

Atoms of most elements associate into very large groups which are big enough to see. Crystals of metals are composed of extremely large groups of atoms arranged in a definite geometric pattern which gives rise to the definite shape of the crystal. The nuclei of the atoms

are separated by a cloud of electrons. The outer electrons of each atom are loosely held so it is easy for these electrons to move through the crystal, i.e., the metal conducts electricity readily. It is also possible for the nuclei to slip past one another through the electron clouds without breaking apart so metals are malleable and ductile. Atoms of most nonmetallic elements form crystals in which there are pairs of electrons holding the atoms together in a definite geometric pattern. These pairs of electrons are somewhat localized in space. Crystals of nonmetallic elements are brittle because the force of attraction between atoms cannot be readily shifted from one to another. Atoms of several nonmetallic elements associate into groups of only two atoms. These are the gaseous elements H_2, N_2, O_2, F_2, and Cl_2. The atoms of the elements He, Ne, A, Kr, Xe, and Rn have no tendency to hook up with themselves or any other atoms. They are monatomic gases and chemically inert.

Ionic Bonding

As previously noted Helium has 2 and each of the other inert elements has 8 electrons in the outermost main energy level and that all of the inner levels are filled to capacity with electrons. A study of simple compounds involving only two atoms reveals that atoms of elements other than these inert ones react in a way to approach the condition of 2 or of 8 electrons in the outermost orbit or energy level. The alkali metals and the alkaline earth metals tend to lose their outermost electrons to form positively charged ions when they react chemically. The halogens tend to gain an electron to form negatively charged ions when they react chemically. When a chemical reaction produces negatively and positively charged ions, the electrostatic attractions between opposite charges cause the ions to assume a geometrical arrangement which produces a hard, brittle crystal. The electrostatic attraction which holds the ions together in this crystal lattice is called an ionic bond.

Two atoms may form a molecule by sharing pairs of electrons between them instead of transfering electrons from one to the other. The molecule so formed is more stable (less reactive chemically) than are the uncombined atoms. The interplay of electromagnetic forces between the two positively charged nuclei and the total array of electrons in the molecule holds atoms together with what we term a covalent bond. There are weak residual forces of attraction between molecules which cause them to cluster together to form liquids when the temperature is lowered and to form geometric patterns of crystalline solids when the temperature is lowered still further. The kinetic-molecular theory is designed to explain the behavior of molecules in the solid, liquid, and gaseous states.

Ionic bonding is usually found only between one kind of positively charged ion and one kind of negatively charged ion though some mixed crystals are known. On the other hand, covalent bonds may be formed among groups of only a few or of many thousands of atoms. Carbon atoms readily form covalent bonds with themselves as well as with several other elements. Hundreds of thousands of carbon compounds are known and the study of these compounds is called organic chemistry. Some common ions are formed by the covalent bonding of several atoms into one particle. If extra electrons are needed to form the covalent bonds in such a complex ion, then the ion bears a negative charge. If electrons are left over in the formation of the complex ion, it then bears a positive charge. Most chemical bonds are neither purely ionic nor purely covalent but lie between these two extremes. Many properties

(See page 559)

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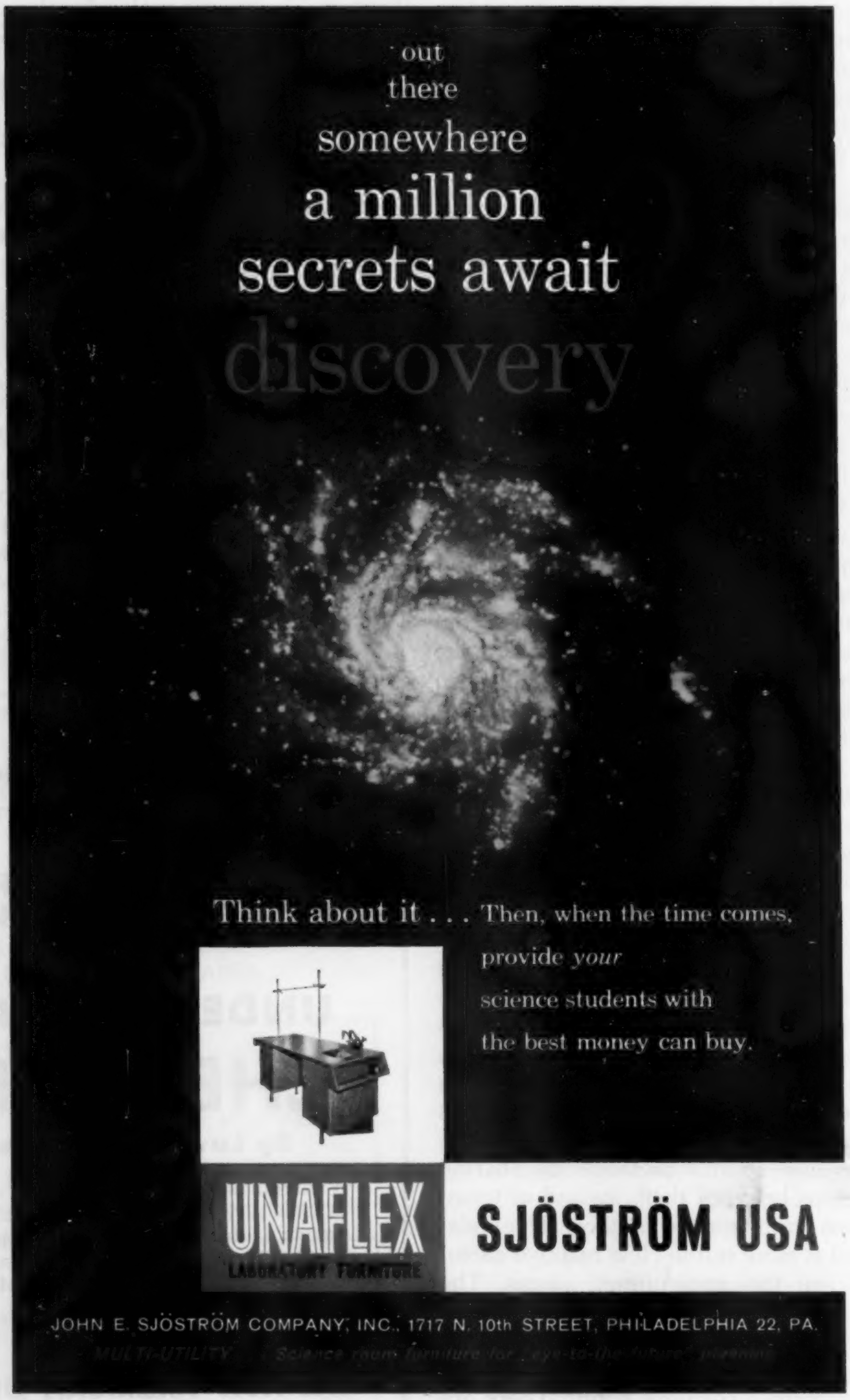

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of compounds can be explained in terms of the partially ionic—partially covalent nature of the bonds in the compound.

When atoms react chemically they do so because the configuration of nuclei and electrons in the compound is more stable than the configurations of the separate atoms. Changing the conditions to which the reacting system is subjected may change the relative stabilities. At high temperatures molecules tend to be shaken apart into atoms or smaller molecules. HCl is the stable form at room temperature but H_2 and Cl_2 are the stable forms at high temperatures. At still higher temperatures H atoms and Cl atoms are the stable forms. On the other hand, the shaking apart produced by high temperatures may be lessened by applying high pressures to systems in which the breaking-up process increases the total number of molecules present in the system. When a reaction takes place under conditions lying between extremes of pressure and temperature, an equilibrium is set up. The equilibrium is a dynamic one (rather than a static one) because both the forward and reverse reactions are going on simultaneously. Because the forward and reverse rates are equal, there is no observable change in the system when it is in equilibrium. The factors which determine the equilibrium state for a particular reaction are pressure, temperature, and the concentrations of the various substances present. When any of these factors is increased (or decreased) the equilibrium will shift so that this increase (or decrease) will be partially undone. To make a reaction go to completion, we adjust the temperature, pressure, and concentrations to favor the reaction we want to take place. Removing a product of the reaction as fast as it is formed is especially effective in making a reaction go to completion.

The rate at which a reaction proceeds depends upon the inherent reactivity of the materials brought together, the sizes of the particles of any solids involved, the concentrations of solutions and gases, the temperature, and whether or not a catalyst is present. The speed of a reaction roughly doubles with a ten-degree rise in temperature. The effect of a catalyst cannot be predicted theoretically but must be determined experimentally.

Whenever substances react chemically, energy is produced or consumed. This energy usually appears in the form of heat but electricity and light may be involved. During chemical reactions which produce energy, the potential energy resident in the configurations of electrons around the nuclei of various atoms is converted into other forms of energy, and the configurations of electrons in the atoms of the products have less potential energy.

In developing the framework of unifying concepts described in the preceding paragraphs, the thoughtful teacher will show how these concepts grow out of experimental phenomena and laboratory data. To present them as ideas to be accepted *in toto* on faith and to be memorized without tracing their origin and development would be futile. The experimental and descriptive chemistry involved in building up this framework of concepts can be drawn from a rich variety of chemical phenomena. It need not be very different from that now included in many high school courses though it may be somewhat less extensive than is usually the case. It would include the usual studies of mixtures, elements, and compounds, quantitative relations involving weights and volumes, gram-atomic and gram-molecular weights, balancing of chemical equations, studies of gases, liquids, and solids, solutions of nonelectrolytes and electrolytes, acids, bases and salts, simple oxidation-reduction systems, and activity series. A study of the simple compounds of hydrogen, carbon, nitrogen, oxygen, sodium, magnesium, sulfur, chlorine, and two or three additional metals should present sufficient chemical data for the development of the concepts enumerated.

Conclusion

Whatever the high school teacher decides to include by way of subject matter to be studied, it is vitally important that he continually impress upon his students that the categories and classifications we set up in studying chemistry are for convenience only—that in nature there are no sharp boundaries between man-made classifications such as ionic and covalent bonds, strong and weak electrolytes, metals and nonmetals, etc. Borderline cases are always encountered in nature. It is important also to stress that theories are always imperfect and incomplete but that they are useful in spite of their imperfections. Indeed, the incompleteness of our knowledge is the driving force of all research. And thirdly, it is important that students be taught to keep an open mind and a flexible approach to new ideas, for willingness to change and to modify our concepts is the *sine qua non* for the advancement of science.

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Rebuilding the Science Program

Physics

Why Do You Teach Physics?

By JOHN W. RENNER

Associate Executive Secretary, NSTA

NOTE: This article, submitted early in the year, is based on research done by the author as Assistant Professor of Physics and Education and Acting Director of the Physics Department at The Creighton University, Omaha, Nebraska.

MANY students in high school physics study this subject with the thought that this will aid them either in their study of physics in college or that the successful completion of high school physics will admit them to advanced courses of study in physics at college. The purpose of this paper is to explore the two possible contributions of high school physics. More specifically, this article will advance answers to the following questions.

1. Do colleges consider high school physics courses as being valuable enough to grant advanced standing in physics or to change the type of beginning physics course the student will take?
2. What are the views held by college physics professors as to the value of high school physics?

In order to answer these questions, data on what first-year programs in physics were offered by colleges had to be gathered. Consequently, a questionnaire was developed and sent to the physics departments in sixty-four institutions of higher education in eight midwestern states. These institutions were selected at random from the private[1] and state-controlled institutions of the various states. Forty-seven replies were received, and three of these replies were not usable. The forty-four replies sent in represented seventeen private institutions and twenty-seven state-controlled institutions.

The data obtained from the questionnaire are summarized in Table I.

[1] The term "private institution" in this paper includes institutions administered by a church, as well as institutions administered by other private means.

When each of the first-year physics courses which are taught by the institutions in the sample were studied, they were found to fall into four categories.

Category I: General Physics for all types of Students.
Category II: Physics for Students of the Liberal Arts.
Category III: Physics for Physical Science Majors and Engineering Students.
Category IV: Physics for Pre-dental, Pre-medical, Pharmacy, and Biological Science Students.

TABLE I

Number of First Year Physics Courses Offered by the Participating Institutions

Number of First Year Courses Taught	Number of Private Institutions Offering	Number of State Controlled Institutions Offering
1	3	12
2	11	7
3	2	4
4	1	4

TABLE II

Number of Different Types of First Year Physics Courses Offered by Participating Institutions

Course Category	Number Offered by Private Institutions	Number Offered by State Controlled Institutions
I	3	12
II	13	17
III	14	18
IV	5	7

The number of courses offered by the institutions in the sample are summarized by category in Table II.

In reviewing the data submitted on the questionnaire, only two institutions took cognizance of high school physics when admitting a student to a course in one of the foregoing categories. Both of these institutions were privately-controlled institutions. One institution admitted students to first-year physics during their first year of college if they had completed one year of high school physics with a minimum grade of "B." The second institution admitted first-year students to beginning physics if they had successfully completed one year of high school physics. The units of study covered in both of these courses (listed in the questionnaire by the physics departments offering them) were the units of a conventional physics course, i.e., mechanics, heat, sound, electricity, light, and a brief introduction to modern physics. Consequently, these schools recognize the value of high school physics only to the extent that the students' background allows them to study earlier than usual in their college careers essentially the same materials that were studied in high school physics. Of course these units are or may be studied in college in greater detail or more comprehensively than in high school. Undoubtedly, the students develop a much more thorough understanding of the laws of physics. The *breadth* of scientific knowledge, however, which the student possesses is not further enhanced by repeating the study of the same concepts. The reader can satisfy himself that many of the same concepts are studied by merely comparing a high school and a college physics text. These colleges are to be congratulated, however, on taking a *long* step in the proper direction by recognizing that high school physics contributes something to the intellectual development of the student. Several institutions in the sample stated that perhaps in the future the level of high school physics will be raised to such a degree that college work can be based upon it.

One point of extreme interest to the investigator was that no institution in the sample indicated that the students coming into physics were examined to see whether or not they were capable of doing advanced work in the traditional topics in physics or work of a nature that would broaden their scope in the physical sciences. One institution did indicate that such a program is contemplated and is presently under review by the department. A second institution reported that testing was sometimes used.

The data which were received allow the fomulation of an answer to the first question which was: *Do colleges consider training in high school physics valuable enough to grant advanced standing in physics or to change the type of beginning physics course the students take?* In view of the data received, the answer to both parts of the foregoing question is "No."

One question in the questionnaire asked whether or not the department offered or was contemplating a first-year course specifically designed for students who have had high school physics, whether or not such a course is desirable, and reason for their answer. The question was asked in order to ascertain whether or not college physics departments favored the introduction of a special course in physics for those who had studied high school physics. The results of this question are shown in Table III.

TABLE III

Should a Special Course in Physics Be Introduced for Students Who Have Completed High School Physics?

	Private Institutions	State Controlled Institutions
In favor	2	1
Opposed	11	15
Not at the present time	3	6
No opinion expressed	1	5

The data in Table III leave little doubt as to the opinion of college physics professors with regard to introducing a special course for students who have completed high school physics. However, some institutions consider that perhaps in the future such a course might be desirable.

Opinion Samples

The second question that this study set out to answer is: *What are the views held by college physics professors as to the value of high school physics?*

Listed below are some of the opinions[2] on high school physics expressed on the questionnaire by the college physics professors in the sample as reason for the opinions they hold on

[2] These are not direct quotes from the questionnaires. The author has taken the liberty of paraphrasing them. This was done in order not to reveal the identity of any contributor.

whether or not a course especially designed for those who have studied high school physics should be introduced. If these opinions are carefully examined, the second question asked in the study can be answered. In addition, these opinions will give further information regarding the statement in question number one—whether or not students who have completed high school physics could be admitted to advanced standing in physics.

1. Students who have had high school physics do no better in college physics than those who have not had high school physics.
2. A thorough training in algebra and trigonometry is more important to success in college physics than is high school physics.
3. Staff time can be more profitably used in introducing physics courses at advanced levels than separating the students in the first-year course.
4. The quality of high school physics courses cannot be relied upon.
5. High school physics textbooks are more interested in how things work than they are in cultivating scientific thinking.
6. Few high school students take courses that are worthwhile.
7. High school physics is presented from a phenomenological point of view; college physics is presented from an analytical standpoint; therefore, there is little correlation between them.
8. Some students would be better off if they had not studied high school physics.
9. High school physics is less significant to success in college physics than are college chemistry and mathematics.
10. A student's ability is more important than having completed high school physics.

The preceding ten statements were selected because they represent the general, over-all opinion of the college physics professors in the sample regarding high school physics. These professors hold the opinion that the value of high school physics ranges between *unimportant* and *harmful*. Several of the respondents indicated a willingness to consider high school physics as a basis for advanced work, if they could be assured of the caliber of high school physics. Other respondents indicated that they were watching the recent developments in high school physics with keen interest. In view of the preceding statements, however, in all probability college physics departments would not today consider high school physics as a basis for admitting a student to advanced work. In general, college physicists consider present-day high school physics to be of little value.

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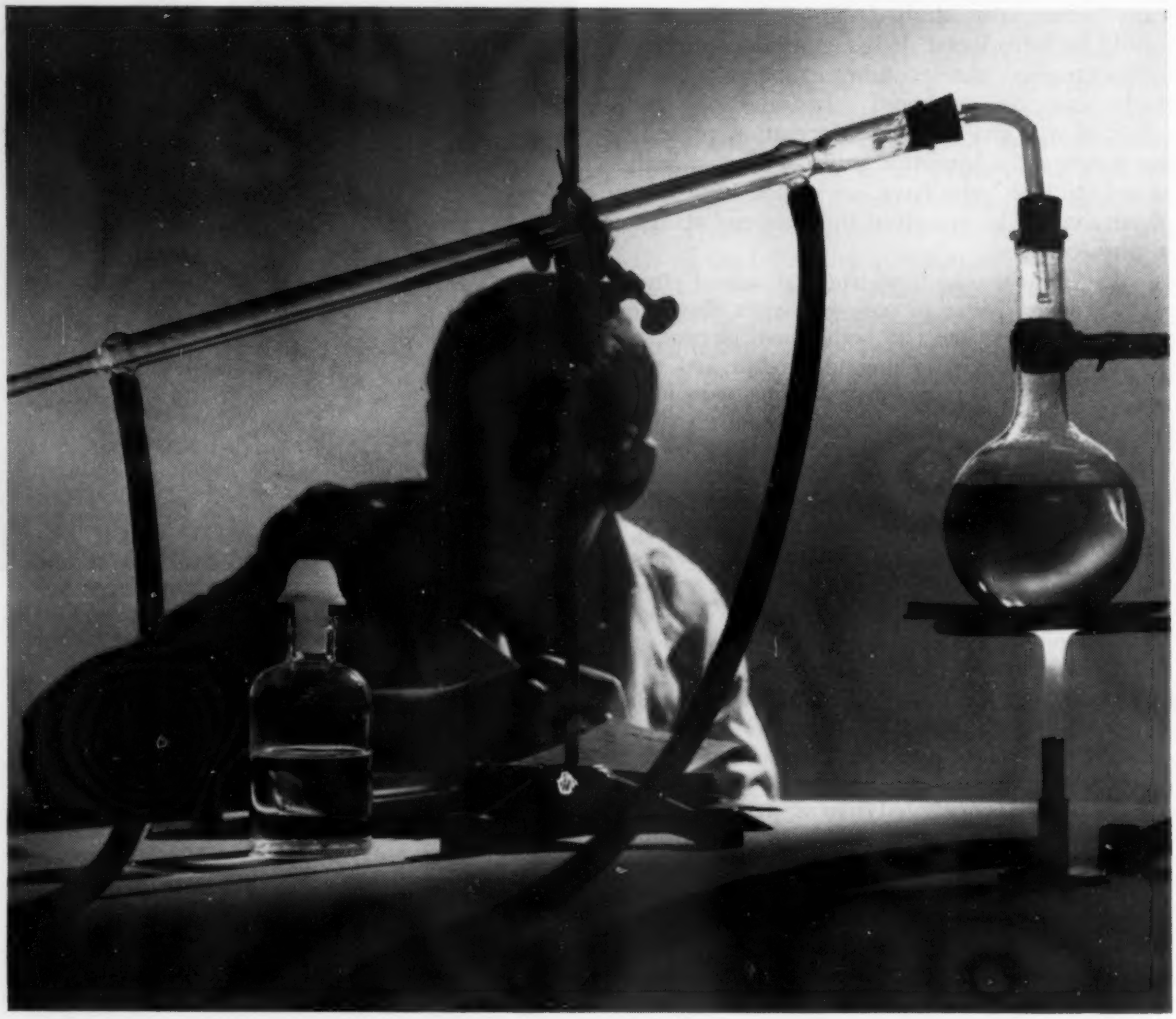
Comprehensive training leads to advance studies in scientific research. Research physicists conduct color perception experiment using optical colorimeter.

Need for Evaluation

The sincerity of the respondents to the questionnaire is above question. Their desire to teach better and more comprehensive physics courses is very genuine. All of the data received, however, were directed toward success in college physics as it is *presently* constituted. There was no concern expressed as to whether or not the type of beginning physics being presented is the type that should be presented. Most of the data received did not indicate a willingness to determine what background the student brings from high school and to build his future education in physics upon that. The writer would be the first to agree that some students would bring little background. Although at a time when accelerated comprehensive education in the sciences is essential, surely institutions of higher education must use all of the students' talent in providing this education.

What could be done in first-year physics programs to provide more comprehensive training in physics? The answer seems to lie in a comprehensive testing program of the first-year physics registrants who have had high school physics and then channeling them into the course best suited to their needs and talents. Those students who



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have not had high school physics should be registered in the usual first-year physics course.

Consider the physical science majors and engineering students. After the test has been evaluated, the group could be divided into two categories. Those, whose high school physics course as indicated by the test was not adequate, would take a conventional first-year course. But those, whose background was adequate, could be permitted to register for the second year of physics, or be enrolled in a course that would not repeat the usual concepts but which would reflect the modern developments in physics. This particular course would be very influential in encouraging the science student to further investigate his chosen profession.

The pre-medical, pre-dental, and liberal arts student (as well as the biological science major) who has had a course in high school physics would, upon examination, also fall into two categories. The first group would consist of those whose high school physics did not give the student an understanding of the basic concepts of physics. This group should be enrolled in a conventional first-year physics course designed for students in this category. That group of students whose examination scores indicate a grasp of the basic fundamentals of physics should be placed in a course that would treat areas of physics not yet studied by the student. Examples of such areas might be:

1. The relationships between basic physical laws and astronomy.
2. A detailed study of sound and the science of hearing.
3. Gravitational fields and their relation to space travel.
4. Nuclear radiation and its relation to medicine and biology.
5. Nuclear radiation dosage and dosage-rate calculations.
6. Nuclear radiation detection devices.
7. Nuclear reactors and their importance to medicine and biology.
8. Alternating currents (without the calculus) and why they are used.
9. Radio and television circuits.

The above groups are but nine from a great many various topics that could be used in such a course. Laboratory experiences for this course would not be necessarily confined to a conventional laboratory as has been the custom. Trips to nearby industrial laboratories where powers of observation can be tested, student-designed experiments and equipment, exercises out of doors plotting the field of radioactive isotopes, and long-term experiments such as the uptake and distribution of radioactive isotopes in plants are examples of some of the laboratory experiences that would replace some of the traditional experiments. An interesting experience is to assign the measurement of the acceleration of gravity as a laboratory experiment. If the Atwood machine and other such devices are barred from use, the students have an interesting and valuable experience in designing apparatus and procedures. The results are usually amazing and satisfying to both the instructor and the students.

What advantages would result from students' studying first-year physics courses such as those outlined in this paper? Assuming that only those students who had acquired a sufficient background in high school physics would be selected, there are two principal advantages.

1. The student's training in science would be more comprehensive. In today's technological world, this certainly is a desirable objective.
2. Students could be given experiences that would be closer to the activities pursued by the professional scientist than those they had in the present first-year physics course. Such experience would allow the student to gain greater facility with the purpose and use of the scientific method than he had initially acquired.

The Future

If high school physics is not utilized by our colleges, as the data presented in this paper show, then the question "Why do you teach physics?" must be asked. Should physics be abandoned in our high schools? The chorus of "No" in answer to such a question should be of such magnitude that the threshold of pain is approached. The experiences that students have in high school physics *are* valuable. Students learn the areas of knowledge that comprise physics; they gain an appreciation for measurement; they see, perhaps for the first time in their years of formal education, that science and mathematics complement each other; and for our present culture, a certain amount of physics is essential in a general education. If any steps are to be taken with respect to physics in our high schools, these steps should be toward strengthening it. If this is done, colleges will, in time, recognize that the study of physics in college for all types of students can and should be based on the progress made by the student in high school physics.

The Elementary School Science REPORTER

Elementary Science at the KC Convention

By HAROLD E. TANNENBAUM

Professor of Science Education, State University, College of Education, New Paltz, New York

EDITOR'S NOTE: This is the second of a series of articles on various programs in elementary school science. Mr. Tannenbaum is receiving letters with suggestions on this series from our readers, and we urge all of you to write him your comments.

For everyone with a keen interest in elementary school science, the 1960 Kansas City Convention of NSTA promises to be "the event" of the year. This important phase of science teaching has been given equal billing with secondary school science—witness the theme: "Current Science and the K-12 Program." According to Mrs. Mildred Ballou, elementary teacher of Des Moines, Iowa—Mrs. Ballou is convention co-chairman and is coordinating all of the elementary school science activities at the convention—no less than seven important parts of the Kansas City program have been designed especially for elementary school teachers. As part of President Decker's keynote address, pupil representatives of all grades K through 12 will be interviewed on their science interests and experiences. But this is only the beginning of a whole series of sessions which will appeal to elementary school teachers. Another big event is the scheduled luncheon on Friday, April 1. Professor Joe Zafforoni of the University of Nebraska is the featured speaker. He will discuss "The Case of Mrs. Doe."

Otis Allen of Greenwood, Mississippi, is in charge of an old favorite, the "Here's How I Do It" sessions. Mr. Allen has promised two elementary science sessions with four or five presentations in each. Barbara Henderson of the Kansas City Board of Education is arranging visits to see demonstration teaching in primary and intermediate grades. She, too, assures us that there will be plenty of interesting lessons with stimulating ideas. Then there are the children's exhibits. This phase of the convention will portray the growth of ideas, K through 12, in selected areas of science. The pupils' exhibits, together with a "curriculum swapshop" being organized by George Mathes of Denver, should be a great source of help to elementary school teachers in their professional work. Also, special efforts are being made to encourage commercial exhibitors of teaching materials to include materials for use in elementary school classrooms and for the teachers.

Sixteen Workshops

Finally, there are the workshops for elementary school teachers. Because of the demands that were expressed by last year's participants in Atlantic City, these workshops have been expanded so that many more people will be able to attend. An interesting new plan is being tried. There are to be sixteen workshops in all, each accommodating 20 participants. The workshops will be divided among four areas—the sciences; electricity; the changing modern world; and special topics. In each of these four areas, the four workshops will give special help to a particular group of teachers. There will be a workshop in each area for primary grade teachers, one for intermediate grade teachers, one for junior high school teachers, and one for supervisors.

Leaders of these workshops are among the outstanding science education people in the country, and it is a real opportunity to be able to work for several hours under the guidance of these expert teachers. There will also be a chance to

establish these workshop sessions in a sound perspective through a lecture and discussion period under the guidance of Dr. Walter Thurber, Cortland State Teachers College, New York. And there will be time to share some of the experiences of the various groups through a fair and exhibit on Saturday morning, April 2. All in all, these workshops* should prove to be a most worthwhile experience.

Special Sessions

But these various activities are not isolated, special sessions which have been added to the program in the interest of the elementary school teachers. It is in the light of the convention theme that these various sessions are being organized. Being aware of the many new science programs that are being introduced in schools throughout the nation, it is most heartening to see the amount of time and effort being spent on building the elementary school science program into the entire framework of science education. And the general sessions of the convention reflect this concern for a unified, total science curriculum from elementary school through high school. The supervisors, who will meet on Tuesday, March 29, are stressing the interrelationships among the many phases of the school science programs. The Association for the Education of Teachers in Science—also meeting that Tuesday—are deeply concerned with the science preparation of elementary and junior high school science teachers.

What it amounts to is that the science curriculum and science education are now being seen in a much broader perspective, and elementary school science has become an important part of this new picture. And, best of all, the old view—the view which separated biology teachers from physics teachers and from chemistry teachers and from earth science teachers—is being replaced with new insights. In place of this atomized approach to science teaching has come a unified view of the total science job in American education with an assignment of special phases of the task to different parts of the school system—and one of the most important assignments is to elementary school teachers.

The NSTA convention—following the lead of NSTA national policy—seeks to build a sound program in science for elementary school education.

* Note: The workshops are being organized and will be coordinated by Harold E. Tannenbaum.

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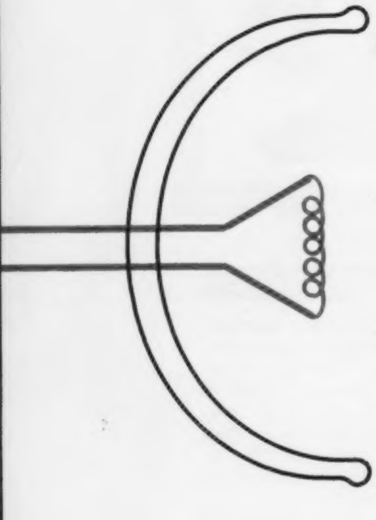

focusing heat waves

By CALVIN F. GRASS

Associate Professor, Castleton Teachers College, Castleton, Vermont

THE use of reflectors to change the direction of and to concentrate energy is fairly well known. Many students have used reflector ovens while on camping trips. The concentration of light energy using hemispherical reflectors can be easily demonstrated in the laboratory, if concave mirrors are available. In most physics courses a study is made of the laws of reflection, especially that of light. The focusing of heat energy, however, by concave mirrors is often overlooked because of the hazard involved in the use of phosphorus in the classic demonstration. A safe experiment which shows the focusing of heat energy can be performed by students in the laboratory or at home. This may be introduced in any physics course.

The use of commercially supplied parabolic reflectors for laboratory use is convenient but may present such a cost factor that few teachers would consider purchasing quantity items. Little difficulty is encountered in obtaining reflectors from old automobile headlights. A pair of these when mounted on wood or metal stands provides a valuable and interesting piece of equipment.

One experiment using these reflectors consists of two parts. First, there is the necessity of determining the principal focus of each reflector. This can be done by using a modified optical bench or by focusing the image of a distant object on a piece of ground glass, tracing or wax paper mounted in a cardboard, wood, or metal holder.

Having obtained the focal points of the reflectors the student may now investigate the effect of intervening distance on the transfer of heat energy in air. This may be done by suspending a thermometer in such a manner that the bulb is at the focal point of the reflector. At the focal point of the second reflector place a piece of

TABLE 1—Data Collected During One Trial

Distance	I	E	T_r	T_3	T_4	T_5	T_6	T_7	T_8
100	6.5	4	25	45	47.5	50	51	52	52.5
90	6.5	4	25	46	48	51	52	53	54
80	6.5	4	25	54.5	57	59	60.5	61	61.5
70	6.5	4	25	57	59	60.5	62	62.5	63
60	6.5	4	25	64	67	69	71	71.5	72
50	6.5	4	25	73	80	84	86.5	87.5	89
40	6.5	4	25	85	90	98	99	100	102
30	6.5	4	25	91	102	107	110	112	114
20	6.5	4	25	119	128	132	136.5	139	142
10	6.5	4	25	126	134	135	137	141	145

Distance is distance in cm between reflectors
T_r is temperature (°C) of room
T_3 is temperature (°C) after 3 minutes
T_4 is temperature (°C) after 4 minutes
T_5 is temperature (°C) after 5 minutes
T_6 is temperature (°C) after 6 minutes
T_7 is temperature (°C) after 7 minutes
T_8 is temperature (°C) after 8 minutes
I is current in amperes
E is voltage in volts

nichrome wire which is heated by an electric current. A rheostat, voltmeter, and ammeter connected in this circuit will insure a constant supply of heat. A length of nichrome wire 15 cm long is first coiled around a small finish nail. The nail is then removed and the coil is attached to two of the leads in the base of the reflector (bulb is first broken and glass removed). The two reflectors may now be placed facing each other, and data collected as the distance between the two is varied. If the distance between the two reflectors is held constant the variation of heat with a change in current can be demonstrated.

If the student wishes to determine the transfer of heat in a variety of gases two small reflectors may be mounted in a tube which can be filled, in turn, with whatever gases are available. As a caution, only gases which will not burn should be used. If a cardboard mailing tube is used, a section may be removed and be replaced with a piece of plastic to enable the student to see the position of the reflectors and thermometer.

The data collected will provide a basis for much discussion and additional mathematical consideration. One question which might be asked is, "How does temperature rise vary with the distance between the reflectors?"

The physical setup for this experiment is simple, yet the student will be impressed by the measures and *caution* necessary to obtain data which are accurate and can be reproduced.

The values in Table I represent data taken during one trial. Table II gives the difference between room temperature and temperatures at various time intervals after the thermometer has been placed at the focal point of the reflector. Table III shows the conversion of T_8 (tempera-

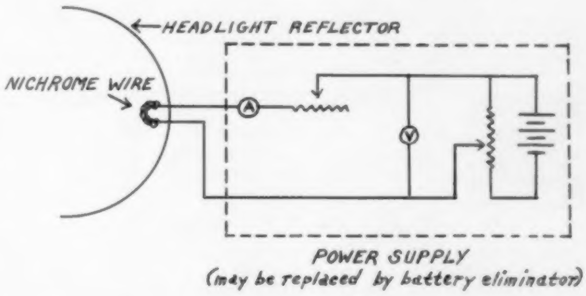

Figure 1. Diagram showing connection of power supply to nichrome wire.

TABLE II

Distance	T_3-T_r	T_4-T_r	T_5-T_r	T_6-T_r	T_7-T_r	T_8-T_r
100	20	22.5	25	26	27	27.5
90	21	23	26	27	28	29
80	29.5	32	34	35.5	36	36.5
70	32	34	35.5	37	37.5	38
60	39	42	44	46	46.5	47
50	48	55	59	61.5	62.5	64
40	60	65	73	74	75	77
30	66	77	82	85	87	89
20	94	103	107	111.5	114	117
10	101	109	110	112	116	120

TABLE III

Distance	T_8	$T_{°K}$
100	52.5	325.5
90	54	327
80	61.5	334.5
70	63	336
60	72	345
50	89	362
40	102	375
30	114	387
20	142	415
10	145	418

$T_{°K} = T_8 + 273$

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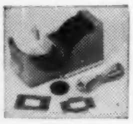

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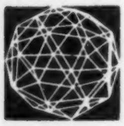

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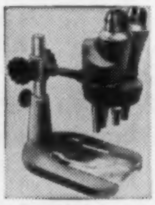

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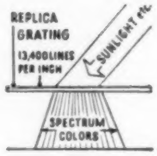

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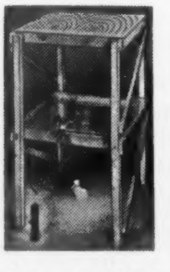

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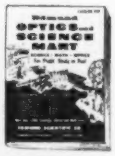

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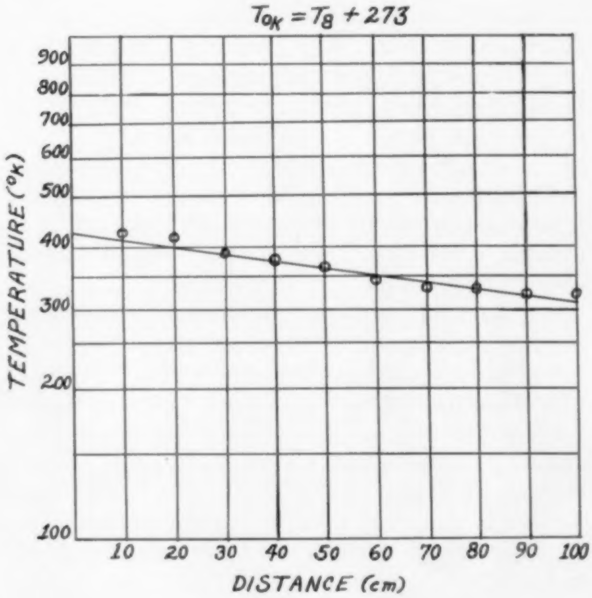
TABLE IV

Distance	T_8-T_r	T_{oK}
100	27.5	300.5
90	29	302
80	36.5	309.5
70	38	311
60	47	320
50	64	337
40	77	350
30	89	362
20	117	390
10	120	393

$T_{oK} = (T_8\text{-}T_r) + 273$

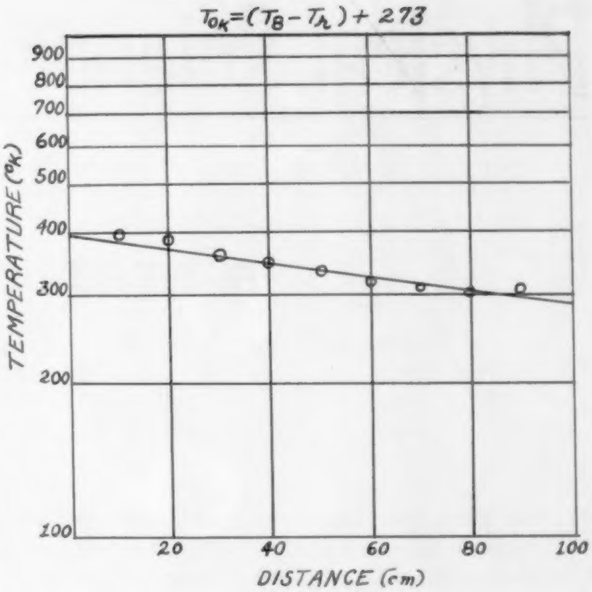
ture after thermometer has been in place 8 minutes) to absolute temperature (degrees Kelvin). Finally, Table IV gives the conversion of T_8-T (difference between temperature after 8 minutes and room temperature) to absolute temperature (degrees Kelvin). Graph I is drawn from the data in Table III, and Graph II from data in Table IV.



GRAPH I

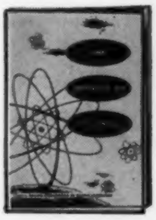
It was found that plotting these data (distance *vs* absolute temperature) on semi-log graph paper gives an approximate straight line from which fair predictions could be made.

The data presented here are merely indicative of the type of values which may be obtained using the apparatus shown in the photographs. The data should not be interpreted as representing detailed research. A serious consideration of



GRAPH II

various facets of this experiment could well be suggestive of a project for students interested in entering a science fair.



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Physical Science Study Committee

A STATUS REPORT

By GILBERT C. FINLAY

Professor of Education and Assistant Dean, College of Education, University of Illinois, Urbana

IT has been two years since the work of the Physical Science Study Committee[1] in developing a secondary school physics course was described in *The Science Teacher*.[2] The current article and the one that follows, together with the summary given on the interpretation and experience of teachers with the course, describe the Committee's work since the earlier report.

The Committee has stated its purposes and activities in some detail in the first annual report.[3] Extensive commentary on the work of the PSSC both by members of the Committee and by observers has been published.[4] The following is given to describe in broad outline the nature of the Committee's work.

The original statement of the Committee's aims still holds: "(1) to plan a course of study in which the major developments of physics, up to the present time, are presented in a logical and integrated whole; (2) to present physics as an intellectual and cultural pursuit which is a part of present-day human activity and achievement; and (3) to assist physics teachers, by means of various teaching aids, to carry out the proposed program."

To these general ends, the Committee is developing a related set of teaching materials: textbooks, laboratory apparatus, laboratory guide books, films, tests, and teacher's guide books.

As a supplement to the course materials, but also with wider applicability, the Committee is producing the Science Study Series. The individual books in this paper-back series vary in nature. Some are historical. Some are detailed expositions of technological applications of physical principles. Some are extensions of topics introduced in the course. Five books in the series are now available.[5] Seventy-five are in some stage of development.

Because the course materials represent a rather significant departure in content and approach from familiar secondary school physics courses, the Committee has encouraged the development of Summer Institutes and other programs designed to familiarize teachers with the plan of the course and the use of materials. The materials, thus far, have been available for instructional use only to teachers who have made special preparation for their use. Classroom experience with the course has been studied both through direct observation, analysis of achievement tests, discussions with teachers, and written reports of their experience. This experience has been, and continues to be, one of the bases for critical review and revision.

Characteristics of PSSC Materials

It is not possible to review in this article the nature and rationale of the choices in pedagogy

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[1] The Committee is administered by Educational Services Incorporated and supported by grants from the National Science Foundation, the Ford Foundation, the Fund for the Advancement of Education, and the Alfred P. Sloan Foundation.

[2] *The Science Teacher*, 24:316-27. November 1957. Elbert P. Little, "From These Beginnings. . . ." Francis L. Friedman, "A Blueprint. . . ." Jerrold R. Zacharias, "Into the Laboratory. . . ." Gilbert C. Finlay, "What Are the Questions?"

[3] *First Annual Report of the Physical Science Study Committee*. The Committee, 164 Main St., Watertown 72, Mass.

[4] "A Symposium: The Physical Science Study Committee." *Harvard Educational Review*, 29:1-36. Winter 1959.

[5] The Science Study Series is published by Anchor Books, Doubleday and Company, Inc., Garden City, New York. The series is available through Wesleyan University Press, Inc., Columbus 16, Ohio. Titles in print include: Francis Bitter, *Magnets*; C. V. Boys, *Soap Bubbles and the Forces Which Mould Them*; Donald R. Griffin, *Echoes of Bats and Men*; Donald J. Hughes, *The Neutron Story*; Patrick M. Hurley, *How Old Is the Earth?*

and content that have been made in the development of the PSSC course. As background for the discussion which follows, a few characteristics of the text and laboratory will be noted. A brief resume almost denies existence of the intertwined learning cycles and the unity of the subject matter that is sought. The references cited earlier provide more detail.

The preliminary version of the text is in four volumes. Volume 1, *The Universe*, is a general introduction to the fundamental ideas of time, space, and matter. Measurement is taught as a tool to answer real questions—to learn by something more than merely authoritative statements. Volume 2, *Optics and Waves*, considers optical phenomena, first pursuing a particle model of light until the theory becomes inadequate to represent the phenomena. A kinematic picture of wave behavior is then explored, principally in the laboratory. The connection with optical phenomena is evident, and the volume closes with an exploration of a wave model for light. Volume 3, *Mechanics*, presents the dynamics of Galileo and Newton, momentum and the conservation of momentum, energy and energy conservation. Volume 4, *Electricity and Modern Physics*, builds on concepts studied earlier in dealing with electrical forces and energy, electromagnetic waves, and the structure of atoms.

The course covers less topical material than usually presented in high school courses in favor of a more penetrating analysis of areas which contribute most heavily to an understanding of an atomic picture of the universe. By developing the meaning of physical models through texts, problems, laboratory work, and films, the course seeks an understanding not only of contemporary science, but how science is forged in human activity. The laboratory is an integral part of the course. In many instances it is the primary learning source. While students cannot recapitulate all the discoveries of physics, the laboratory is designed to give the student an opportunity for personal discovery.

Use and Status of PSSC Materials

For the school year 1957-58, preliminary versions of the text and laboratory experiments for the first half (Volumes 1 and 2) of the course, and tentative materials for the second half (Volumes 3 and 4) were available. Eight teachers who had worked with the Committee in preparing materials taught the course that year. Their experience led to a substantial revision of Volume 1 and contributed to the improvement of the preliminary versions of Volumes 3 and 4.

During the summer of 1958, five 6- to 8-week Institutes enabled more than 300 teachers to familiarize themselves with the PSSC materials. As a part of the experimental development of the program, the preliminary course materials were made available without cost for 1958-59 to all of these teachers. In 1958-59, 278 used the PSSC course.

For that school year, the Committee was able to supply preliminary versions of the text through the first half of Volume 4, a laboratory program and apparatus for Volumes 1, 2, and 3, a partial laboratory program and apparatus for Volume 4, and a preliminary Teacher's Guide for the first three volumes and a part of Volume 4. A number of films were completed during the year. However, with one or two exceptions, these films were not available for use at the most advantageous times.

During the summer of 1959, nearly 700 teachers studied the PSSC materials in fifteen Institutes. For the current school year, the PSSC materials were available at cost to those schools who wished to use them and whose teachers had taught the course last year or had prepared to teach the course through attending an Institute. About 580 teachers are using the course this year.

Printed materials available for use this year are essentially the same as for last year with the addition of a complete Volume 4, partially revised laboratory guides, and a preliminary Teacher's Guide for all four volumes. In addition, about 30 films are available for appropriate scheduling.

The Committee gathered information pertinent to revision and further development during the 1958-59 school year through conferences, regional meetings, reports written by teachers, and analysis of test results.

This experience is making a marked contribution to the Committee's current work. The staff now is revising the text and students' laboratory guides for commercial distribution in the fall of 1960. Sections which have been extensively revised are being used experimentally in a few selected schools. Arrangements are being made for the commercial production of laboratory apparatus. A revision of the Teacher's Guide, but still a preliminary version, will be available in the fall of 1960. Since this year is the first in which an appreciable number

of films have been available, their use is being evaluated. The remaining films associated with the course are being completed.

Before leaving the factual matters relating to the use and status of materials and considering the teachers' appraisals of the course, there is one instance in which the course is being used this year that is of interest because it relates to both topics. This is the use of the course by a high proportion of all physics teachers and students in several areas.

Because the course materials have been used thus far only by teachers who sought special preparation, and this year only where schools have chosen to purchase preliminary materials, many observers have felt that the course was being tried predominantly in atypical situations. It is true that most teachers who have used the PSSC course have had to gain admission to an Institute; be willing to make special preparation for, and use, new and partially complete materials; and accept the prospect of an increase in their daily preparation requirements. Thus far, at least, these characteristics do not seem to be so rarely found that they might be regarded as atypical. Additional experience will cast more light on this matter.

It is also true that the students who have studied the course probably have been, as a group, somewhat more selected in terms of academic aptitude than the American secondary school physics population. However, as is pointed out in the accompanying article by Ferris, because of the large number of classes that have used the course, an appreciable number were typical in terms of academic aptitude distributions.

The extensive use of the course this year by high school physics teachers and students in three major geographical areas in Florida will provide a substantial base for further examination of questions relating to how broadly applicable the PSSC course is.[6] This was made possible through the combined efforts of the Florida State Department of Education, a number of Florida school districts, and Florida State University; and with support from the National Science Foundation for Institute training.

Familiarization of the Florida teachers with the course began with an intensive two-week program in August. A weekly in-service program in each of the three areas enables the teachers both to plan for coming work, and to consider their current teaching problems. Since this program is the first instance in which the PSSC course has been used by nearly all teachers and students in an area, the experience of students and teachers and the data derivable from achievement tests will be studied carefully.

Following the achievement testing report by Mr. Ferris, a summary is given of teachers' judgments on the PSSC course.

[6] There are 3500 students and 72 teachers involved. This represents more than 90 per cent of the total number of physics teachers in two of the areas and about 60 per cent in the third area.

AN ACHIEVEMENT TEST REPORT

By FREDERICK L. FERRIS, JR.

Educational Testing Service, Princeton, New Jersey

SKEPTICS of the PSSC program have expressed concern that the new course is in reality appropriate only to those high school students of exceptionally high scholastic aptitude or "intelligence." Some even go so far as to contend that a group of well-meaning but unrealistic university physicists, oblivious to the limitations of the American adolescent, have created a textbook hopelessly beyond the grasp of all save the ablest 5-10 per cent of U.S. twelfth-grade high school students. Such skeptics are prone to dismiss the often enthusiastic reports of PSSC teachers as being unduly exaggerated.

From the inception of its program, the Physical Science Study Committee has been aware of the need for some reasonably objective basis for assessing the effectiveness of its efforts. The program described by Finlay for collecting feedback through reports from teachers and classroom visitations was regarded as an essential feature in any evaluation of the new course.

Nevertheless, the Committee recognized that using such subjective reports as the only source of evaluation—especially if highly optimistic or favorable—might well be construed as merely reflecting the bias of enthusiasts. Hence, from the outset, a systematic program of achievement testing was built into the development of the course itself.

The aim of the PSSC testing program was twofold. From the instructional point of view, a sequential battery of ten achievement tests was developed for administration throughout the year. These achievement tests were designed to measure the kinds of learning expected of students by authors of the course. In this sense the tests were conceived as an integral part of the instruction process, serving to communicate to students, in terms of *specific tasks* to be performed, the objectives of the course.

From the point of view of evaluation, the same achievement tests were intended to serve an additional role. Insofar as the textbook authors were agreed that the tests did indeed examine the kinds of learning inherent in the concept of the new course (i.e., that the tests had *content validity*), student performance on these tests could provide a partial measure of the extent to which the course objectives had been met. In other words these tests, when used in conjunction with standard measures of verbal and quantitative aptitude, could serve as *criterion measures* for a *self-appraisal* by the Physical Science Study Committee of the success of its efforts to date.

Thus the necessary tools were available to the Committee during the academic year 1958-59 to come up with some reasonably definitive answers to the following questions:

1. Is the group of students enrolled in the PSSC program during 1958-59 representative of the aptitude level for which the course was designed?
2. Is the course generally appropriate to the ability range of students for which the course was designed?
3. Is the course, as many critics had predicted, hopelessly beyond the capacity of students in the lower aptitude ranges of those who normally take physics?

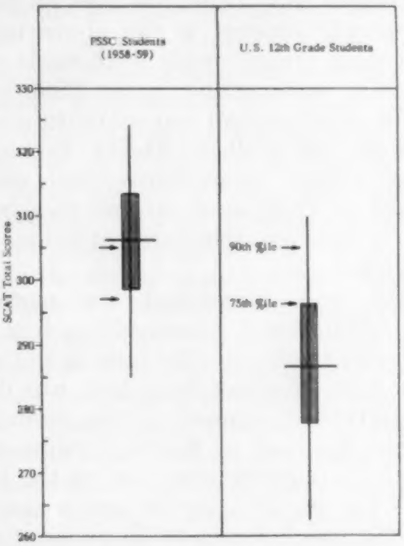
It should be emphasized in this connection that the Committee was concerned only with an *internal evaluation*, or *self-appraisal*. No comparison of the effectiveness of the PSSC course with other methods of secondary school physics instruction was contemplated. Nor, indeed, was any such comparative study even feasible for the simple lack of suitable criterion measures.

To provide answers to the above questions, the following arrangements were made with the 278 schools participating in the PSSC program last year. Each school was asked to administer the School and College Ability Test (SCAT) yielding verbal, quantitative, and composite scores for all PSSC students and thereby establishing control on scholastic aptitude for the "test group."

As the year progressed the participating schools administered sucessively each of the 45-minute objectively scorable tests in the achievement battery. Each of these tests was designed for a particular segment of the course, there being two for each of the four volumes of the text with a comprehensive test on the first two volumes for use at midyear, and a similar test on the last two volumes to be given at the end of the course. Consistent with the aims of the course, nearly every test situation demanded not only a knowledge of the subject matter but also an ability to *use* and *apply* this knowledge in the context of a variety of situations new to the student. In keeping with "standardized" achievement tests in general, it was hoped that the tests would prove to be of middle difficulty for the "test group," assuming the latter to be representative of the aptitude range for which the course was designed. Thus optimal score distributions would find the average student getting a little better than half the questions right, with very few students falling below the score which they would be expected to obtain by random guessing (the mean chance score).

In this connection it should be noted that the tests, like the other course materials including the text, laboratory guide, and teacher's guide, were new and undergoing further development and tryout with a view to subsequent revision. Teachers' comments and a statistical analysis of student performance on the tests were to yield evidence as to the extent to which such revision was indicated. As with any new and untried test materials it was not expected that all of the achievement tests would prove to be of precisely the desired level of difficulty and yield an ideal pattern of score distributions. Rather it was hoped that deviations from the optimum would be sufficiently slight as to permit revision in terms of refinement and minor adjustments.

Scholastic Aptitude Ranges Based on the School and College Ability Test (SCAT)



Percentiles indicated are based on the *national norms group.* In each case, the graphs represent 90 per cent of the group in question; the middle 50 per cent of each group is represented by the broad segment of each graph. Median scores are represented by the short horizontal line across each graph.

Never in the past has there been so widespread and systematic a program of achievement testing for a single course on a nationwide basis. What were the results of all this testing? Were these efforts fruitful and justified?

The vast majority of PSSC teachers, based on an almost complete response to questionnaires sent out at the end of the year, felt that the very sizable amount of valuable class time (as much as 20 class periods) devoted to administration and class discussion of the tests was worthwhile. The consensus seemed to be that the tests led to discussion that served to summarize and clarify the course content and its objectives. In this sense the achievement tests fulfilled the purpose of assisting in the instructional process.

With respect to evaluation and feedback, the following relevant characteristics of the tests used were obtained from an analysis of the data. The test reliabilities of all instruments, including the SCAT test, were satisfactorily high. The mean difficulty of the achievement tests proved a little higher than the ideal; however, all concerned were agreed that the average difficulty of the tests could be adjusted without detracting from the content validity of the tests. The tests did an excellent job of discrimination, especially considering that none of the items had previously been tried out on students. In short, the measurement characteristics of all the PSSC tests were in every way compatible with the standards of excellence maintained by the College Entrance Examination Board.

The data further served to provide definitive answers to the three questions raised above. The results of the aptitude testing showed that approximately 80 per cent of the PSSC students scored better than the 75th percentile of the national norms group of U. S. twelfth-grade students on SCAT (see graphs herein). The PSSC course was designed to be appropriate for that group of U. S. high school students which typically enrolls in physics, the great majority of whom stand in the upper 25 per cent of the ability, or scholastic aptitude range. Thus it can be concluded that the "test group" of students enrolled in the course during 1958-59 was essentially representative of the aptitude range for which the course was designed.

How well did these students do? First, these tests were "hard." They were designed with the expectation that getting half the questions right would represent a *creditable average* level of understanding. The fact that this standard was achieved by the students is regarded as indicative that the course "got across" to the hoped-for degree. The further fact that appreciable numbers of students performed at what might be regarded as highly professional levels—levels that required marked insight and analytical skill, not simply encyclopedic recall—was highly encouraging.

What about differences in achievement by students of varying academic aptitude? A special study was made of the achievement test results for students in each of three aptitude groups as measured by SCAT. *The percentile ranks in all cases refer to standings with respect to the national norms group:*

Group I: Students ranking above the 90th percentile.
Group II: Students ranking between the 90th and 75th percentiles.
Group III: Students ranking below the 75th percentile.

Group I comprises an outstandingly capable group of students—generally representative of material acceptable for admission to the so-called "prestige colleges." Group II may be con-considered to represent the more typical, or "average," American high school physics student—one who would, more likely than not,

score below 500 on the College Board's Scholastic Aptitude test. Group III includes what might be termed the "low-aptitude" physics students, probably representing something less than the lower quarter of those typically enrolled in high school physics.

The achievement tests proved to be "easy" for students in Group I, median scores falling well above the mean scores for the total PSSC "test group," and with score distributions negatively skewed. For students in Group II, the achievement tests were moderately difficult, in terms of the criterion described above. As might be expected, the achievement measures were generally difficult for students in Group III.

However, one striking fact emerged from a comparison of the performance of these three aptitude groups on the battery of achievement tests. There was a marked *overlap* in the score distributions of the respective groups. *A significant and surprisingly high percentage of students in each of the lower aptitude groups performed better on the achievement tests than the median score of the group ranking above the 90th percentile on SCAT.*

The test data suggest that the degree of relationship between academic aptitude measures and achievement as measured by the PSSC physics tests is considerably lower than has been experienced in comparably broad achievement testing programs in science. The data further suggest that the correlation between aptitude test scores and achievement in the course decreases during the year. Further studies are needed to identify and evaluate the pertinent variables. Clinical studies are being planned to investigate more closely the factors related to learning achievement in the PSSC context. However, one thing can be stated already. Many students who rank well below the 90th percentile on an academic aptitude scale penetrated the higher ranges of achievement. Many students below the 75th percentile did well. Consequently, it is now possible to exclude the idea that the PSSC course is appropriate only for students of the highest academic aptitude. A significant fraction of lower aptitude students handle it well. It should be noted that very few students, even in the lowest aptitude group, obtained scores below the mean chance level for any of the achievement tests.

Thus the evidence obtained from the PSSC testing program during 1958-59 overwhelmingly points to the conclusion that, not only is the course well within the capability of the great majority of U. S. high school physics students, but that experience in it is also highly profitable to a sizable percentage of relatively low-aptitude students. Further, the evidence refutes the prophecies of skeptics who surmised that the PSSC course would be appropriate only for the exceptionally "bright" student.

SUMMARY OF JUDGMENTS MADE BY TEACHERS

EDITOR'S NOTE: Due to space limitations and in order to avoid repetition of comments, the following summary prepared by Dr. Finlay will be limited to some of the general questions that are asked most frequently about the course. (We also refer you to the opinions expressed in the Readers' Column of this issue.)

One kind of information which bears on teachers' judgments about the PSSC course is the factual data on the number of teachers who taught the course last year and elected to teach it again this year. Certainly a decision to continue teaching the experimental version of the PSSC course does not constitute an indefinite commitment to do so. The Committee, however, regards the following figures as indicative of a generally favorable reaction.

Of the 278 teachers who taught the course last year, 82 per cent (228) are using it again this year. Thirteen per cent (36) are engaged in graduate study, or are now in positions which do not make it possible for them to use the course this year. Five per cent (14) have either chosen not to teach the course this year, or have not answered an inquiry about their teaching and are presumed not to be continuing with the PSSC course.

At the present stage of development, aside from the achievement testing program described in the accompanying article by Ferris, evaluation of the PSSC course is largely qualitative, though hardly more so than in the case of more familiar approaches to secondary school physics. This

is not meant as an apology for qualitative evaluation. Most of us are familiar with quantified educational measures that are limited to measuring outcomes that are less broad than the totality of those in which we are interested.

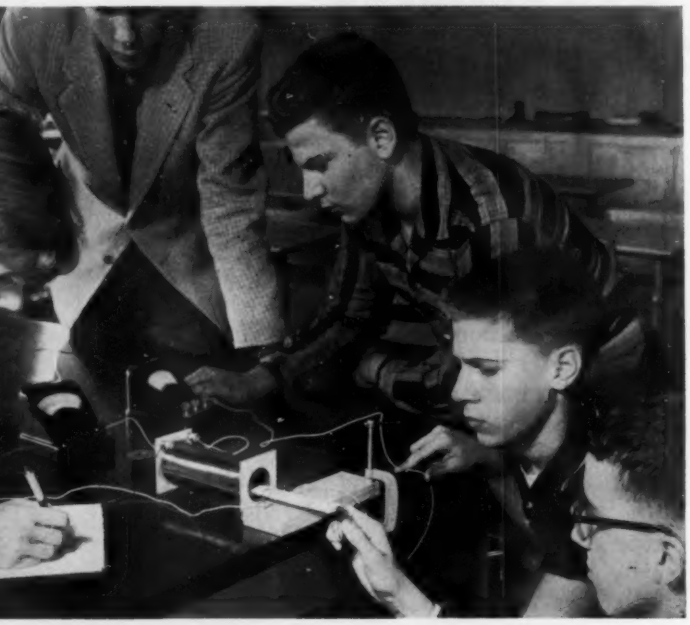
Now let us turn to the qualitative reactions of teachers. Among the teachers who have used the course there are, naturally, a number of reservations about the various characteristics of the course. These range from small "gripes" to carefully considered proposals for major revision.

The most commonly asked questions are typified by "How about the level of difficulty?" "Is the course over the heads of most students?" "With more emphasis on 'physics' and less on the practical applications of physics, how does student interest hold up?" Clearly, teacher opinion on such questions is not uniform. Consider the two following statements which have been chosen to represent the near extremes.

(1) "The course is over the heads of average and poor students."

(2) "The students rated the course as generally more difficult than average . . . Since we used the course for all of our physics classes and had made no particular selection of students, the level of understanding was quite varied. Those students with the most ability and greatest interest did work of considerable depth. Those with the least ability and interest were miles away. Yet I feel that these poorest students finished the year with a better understanding of physics than the average students of previous years. The general difference between the work this year and that of other years was that poor students got a little more this year, and good students got a great deal more. This made the spread between top and bottom considerably greater than before. This is not meant as a complaint. Superior students, some for the first time, found a real challenge."

Students measure the strength of a magnetic field in the center of a solenoid with a current balance. (Lexington High School, Massachusetts.)



Perhaps the following quotations will convey something of the flavor of some of the opinions of other teachers on level of difficulty and student interest.

". . . In general [my] * students found the physics plenty tough. The less capable ones were . . . able to parrot a fundamental concept such as energy conservation but to apply it to a real situation such as in the [experiment on the energy of a simple pendulum] seemed to present a monumental academic task . . . I keep asking myself how these (less capable) students would have fared in a traditional physics course. I have no sure answer but my subjective conclusion is that they would have ended up with about the same marks but with less understanding of fundamental physics. . . ."

". . . My better students (A or B) developed understanding [of the subject matter] much better than in previous years. However, the C and D students seemed to understand only after detailed explanation. The C and D students' understanding was about as usual, but their appreciation of physics and their attention to detail seemed higher. . . ."

"Student response has been both encouraging and disheartening. Encouraging, because students of ability and drive have taken the course in great hunks, and have actively sought for more to do . . . In a few cases the students' growth has been astonishing. This group of students has made every bit of effort put into the course worthwhile. Discouraging, because so many students of ability are completely indifferent or actively antagonistic . . . too many capable students are simply not willing to work hard enough. How well the school can cope with this group remains to be seen. . . ."

"I had an average class. A few students had I.Q.'s between 95 and 100, a few others 120 to 134. The average was 112. The students looked to the course with enthusiasm from the be-

* Represents insertions of the author, Dr. Finlay.

ginning. Low grades in the tests and the difficulty of the subject matter did not diminish this enthusiasm. I feel that the course has something to offer the poor students as well as the good students. . . ."

"Most of the girls admitted that the course helped them to 'think more.' I noticed that they actually stopped to think before answering questions toward the end of the year. They also stated that there was a carry-over of this acquired habit in their other studies. I believe this to be an important result of the PSSC course. If through it we can teach the young to think, we will have given them an invaluable aid. . . ."

"The material of this survey was gleaned from sixty-five seniors . . . The better students commented upon the fundamental nature of the course and upon its unity and order. The second rank students (I do not mean poor students) had a more interesting observation. They noted the painstaking development of the theory and remarked that the course took pains to answer questions they had never cared or thought to ask. This group responded well to the course and were more happy than not to have been awakened. This leads directly to another group, about thirteen in number, who maintained a 'who cares' attitude despite everything. For them the course was too abstract and all the work done was under duress. Outside that group even the poorer students found the course interesting but difficult. . . ."

"The texts are good, and as [name deleted] said when he read them over, 'They contain more physics than I had in my undergraduate work.' I do not think this fact should be minimized from either standpoint. I think there is little doubt that anyone taking this course gets many times the background in and understanding of physics that the old course can give. One the other hand, in the average high school, the students have never learned to *study* the material but have been led to believe that *reading* it fulfills their obligation . . . Practically all my students said it was the hardest course they had ever taken, and the same number said it was the best."

"My students reported that in their opinion, [these volumes] were written by physicists to please themselves and other physicists and not for secondary school students . . . the writing of the text has tended to obscure the facts, burying them in a vast sea of explanatory words. It is too hard for the student to get at the important ideas."

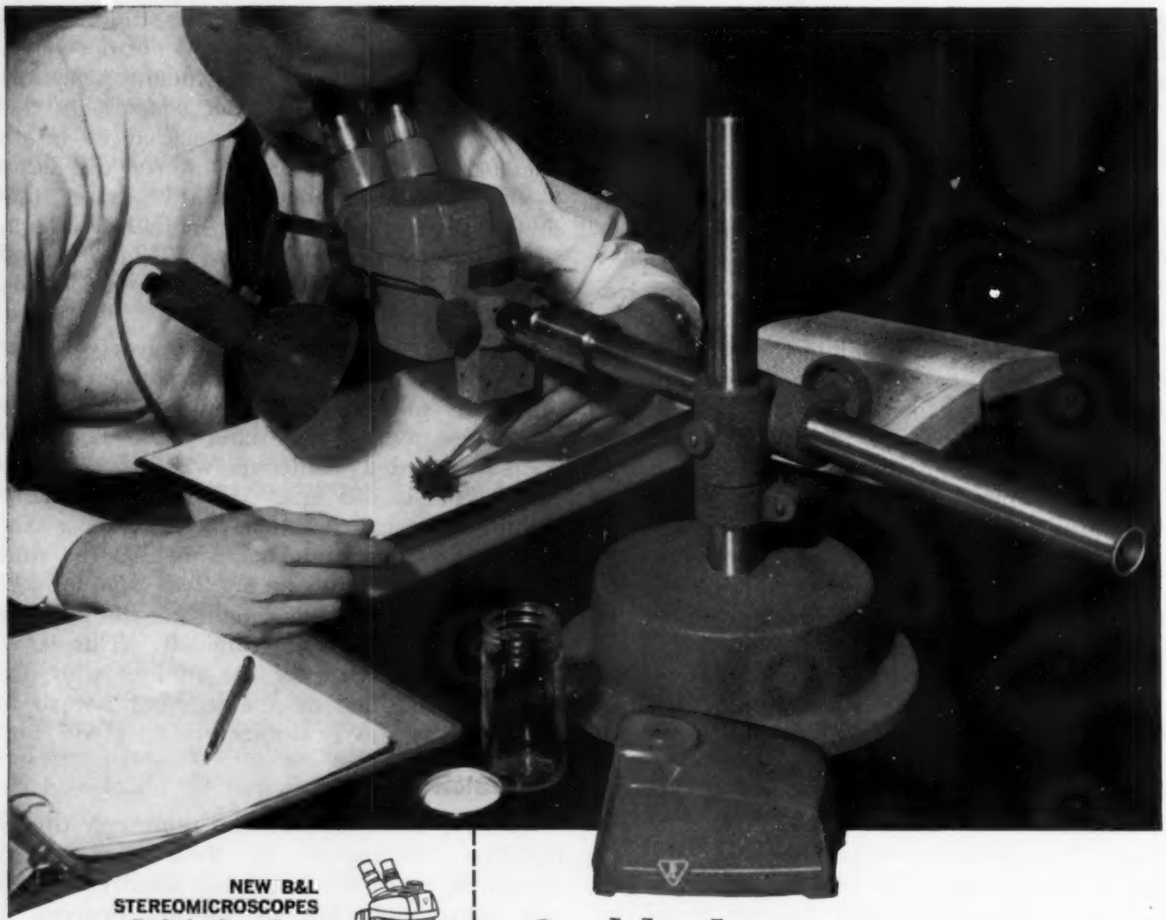
"In general I feel that the students liked the course, even many who did not do well on the tests . . . A number of students who ordinarily get A's or B's in other courses got their first C this year. They appeared to be the 'memorizers' and apparently never did adjust to the different approach. Hard workers, most of them, they learned their math by plugging in numbers in the equations. 'Which formula do I use in this problem?' was a common question from them. . . ."

"I have been teaching physics for two years. The first year I presented a traditional course and this year I used the PSSC course. I found that there was a vast difference. The PSSC course offered a challenge, whereas the traditional course did not. Students taking the traditional course felt that physics was a snap. They were misled into believing that the study of science and engineering was simple . . . From the foregoing one might get the idea that the PSSC course is too difficult. This is not true. It is difficult for the student who does not want to think or analyze, but not so for the student who is sincerely interested."

Conclusion

Clearly, such statements represent diverse opinions. Moreover, by their own various standards, many teachers have achieved success and satisfaction, but in varying degrees, in teaching the PSSC course. From the mass of data of which the above is a minute part, and including the achievement test data reported by Ferris, the conclusion seems warranted that "success" in teaching and learning the PSSC course is not limited by an inherent level of difficulty too high for the secondary school audience for which the course is intended. Differences among individual students and classes of students with reference to motivational problems, for example, seem to be a much more affective factor than the course being inherently too difficult. This is not to suggest that problems of inherent difficulty of concept and approach and problems of motivation are completely separable. Neither are they exactly the same problem. That a significant number of teachers were successful with average students bears this out.

With the general conviction that its work is not far from the intended mark, the Committee is using the information from last year's trials to press forward in the improvement of its course materials.



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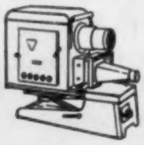

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Classroom Ideas

Physics

A Multipurpose Experiment

By ROBERT G. DOTY, Canby Union High School, Canby, Oregon

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA and sponsored by the National Cancer Institute, U. S. Public Health Service.

The purpose of this report is to illustrate how one experiment, using equipment available in any school, can be used to provide simultaneous emphasis on three phases of laboratory instruction which are frequently overlooked.

Background

In considering reaction kinetics, energy absorption-molecular velocity relationships, or the variation in functioning of similar manufactured items, the application of a distribution curve is often essential to an adequate understanding of the observed results. It is the writer's experience that "the curve" is a rote phrase for most high school students, even though it frequently applies directly to them in the form of grades received.

The experiment described here is not a new one, and it has appeared in various forms in beginning high school texts. The writer's modifications, however, deal specifically with the following items in addition to the production of a distribution curve:

1. The effect of inadequate sampling.
2. The effect of individual variations in experimental technique.
3. The problem of graphical averaging of data.

Method

The general plan of the experiment follows, accompanied by a discussion of the items which the writer has found useful in implementing the objectives of the experiment.

Apparatus required: (1) A suitable group of similar objects for weight measurement; (2) Balances. (*Comment*—since this will be, in most instances, a macro-measurement exercise, care must be taken to insure that the variations in the specimens can be recorded with the apparatus on hand. The writer used marbles of approximately equal diameter, whose weight variation approximated 9 centigrams, and 16-penny nails work equally well.)*

Procedure: (1) Students weigh as many items as possible in the time available; (*Comment*—in a one-hour class period, an average student should be able to record 50-60 items.) (2) Recorded weights are tallied into suitable ranges in terms of ± variations observed, and distribution curves are prepared for both individual and class totals. (*Comment*—the procedure is assisted, with no significant loss in utility, by previously determining an average measurement and then arbitrarily assigning range limits.)

Application

In terms of the objectives of the experiment, the method suggested lends itself well in these ways:

Range (grams)		4.70-4.79	4.80-4.89	4.90-4.99	5.00-5.09	5.10-5.19	5.20-5.29	5.30-5.39
Class Totals	#1	31	40	26	17	55	29	17
	#2	18	21	34	33	47	25	29
	#3	24	36	36	13	44	28	26
	#4	27	26	49	20	30	51	38

FIGURE 1a: Partial class totals of weighings, using the same equipment and samples.

1. The effect of inadequate sampling is rather evident if both the individual and class curves are plotted on the same graph. A nice feature of this plan is that quite frequently the individual "curve" will be almost a straight line!

2. The effect of individual variations in experimental technique is shown effectively, if

*Represent remarks by the author.

there are several classes which perform the same experiment with the same samples and balances. Comparing the various class totals and graphs usually reveals some interesting facts, as indicated by the table and graph in Figure 1 (a and b).

3. The problem of graphical averaging of data is met in attempting to produce a smooth-line distribution curve from a series of seemingly independent points. It is also desirable to compare the usefulness of such a smooth-line presentation with one constructed on a point-connected-to-point basis.

Summary

The experiment described finds use in presenting the high school science student with a method by which he can observe, directly, the importance of adequate sampling, precision measurement, and graphical averaging of data. The procedure is such that a wide variety of measurements (weight or linear) may be employed with equally successful results, making the problem a laboratory exercise applicable in almost any school situation.

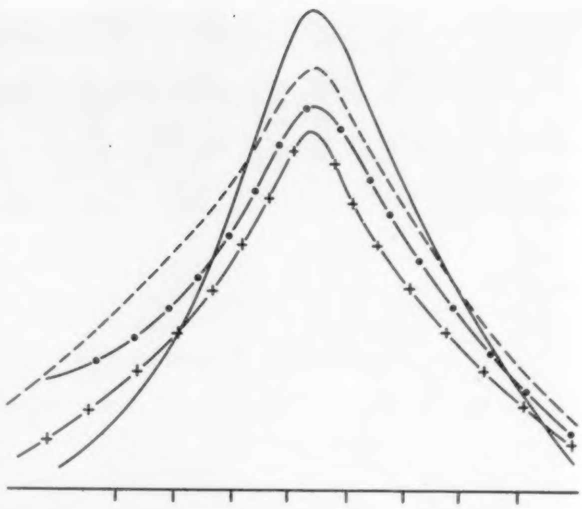

FIGURE 1b: Distribution curves of four class weighings, using the same equipment and samples.

THE SKY IS THE LIMIT

The fiction of Jules Verne is rapidly becoming fact as the world begins to adapt to a new "space age". Satellites are now in orbit. Sending a rocket to the moon is under active discussion. Outer space travel is sufficiently close for the conducting of military experiments to simulate its conditions.

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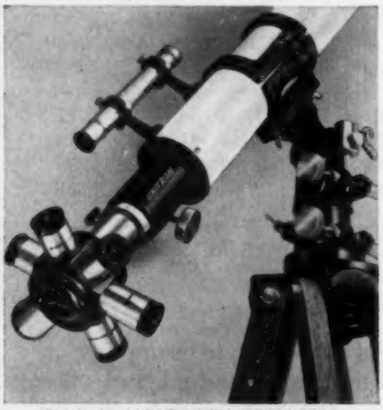

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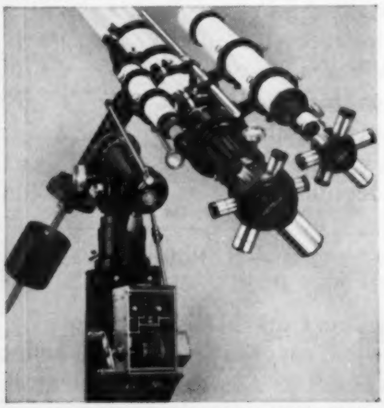

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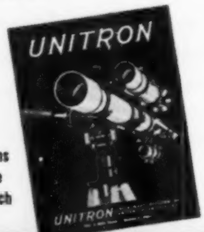

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Physics

Experiments in Modern Physics

By MICHAEL FIASCA, Science Teacher, Beaverton High School, Beaverton, Oregon

EDITOR'S NOTE: The two experiments comprised in this article are examples of approaches which have been developed by the author for introducing concepts in modern physics to high school students. In each instance the device is a provocative demonstration of an experiment which might serve as a springboard into the theoretical discussion of the problem involved. The evidence is first established by the experiment or demonstration, and then the questions of "how" or "why" an experiment is done are given significance.

The author has devised other lessons or demonstrations in this area, and will be glad to correspond with teachers who are interested in exchanging ideas with him.

EXPERIMENT 1: PHOSPHORS AND TEMPERATURE

Purpose

To determine the effect of temperature on phosphorescence.

Materials

A zinc-sulfide phosphorescent powder (the green phosphor gives the best results); a ½-lb. slab of dry ice; a small square of aluminum sheet approximately one inch square; a "purple x" GE light bulb—250 watts, 115 volts. (The special light bulb is not necessary for any light source will do, but the "purple x" is more effective.)

Procedure

Sprinkle over the center portion of the aluminum plate a small portion of the phosphor, then spread it evenly over the surface. Next place the phosphor under the light source for a few seconds, turn off the lamp and all other lights in the room. (The darker the room the better you will be able to make observations.) Now place the aluminum plate with the phosphor on the dry ice. In a few moments the glow will cease. If the plate is now placed in contact with the back of your hand, the glow will again become visible.

Discussion

Solids such as zinc sulfide crystals are described (for analogy only) as having energy bands. (See Figure 1.) Electrons are lodged normally in the *V* band but may be given sufficient energy to send them to the *C* band.

In our experiment this is accomplished when the electron is struck by a photon of ultraviolet light from the light source. (A photon is a unit packet of light energy.) As a result of the collision of the photon and the electron, the electron may instantaneously jump from the *V* energy band to the *C* energy band. The arrow to the left of the energy diagram shows that energy is increasing from bottom to top; thus the energy the electron possesses when in the *C* band is greater than the energy it had when it resided in the *V* band. This process is shown in Figure 2 (a and b).

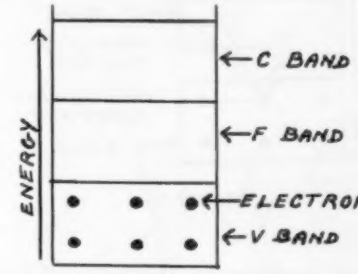

FIGURE 1

The energy bands in a zinc sulfide crystal. It must be remembered that bands such as these do not really exist in such a crystal, but are merely a physicist's way of explaining the behavior of such materials.

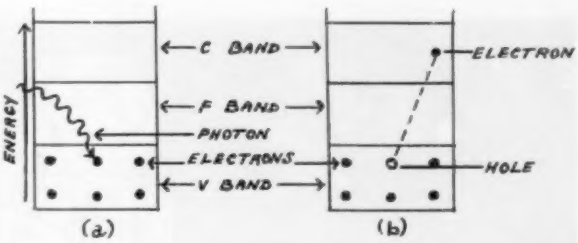

FIGURE 2

Figure 2(a) shows an electron being struck by a photon of ultraviolet light. Figure 2(b) shows the electron moving from the V band to the C band. In this way it absorbs the energy the photon possessed. Note also that a "hole" remains which was left by the electron.

It must be made clear that the process pictured in Figure 2 takes place between millions upon millions of electrons. Electrons can also return to the *V* band; in so doing they must liberate the energy they have acquired. This is an example of the Law of Conservation of Energy. In this particular instance, energy is given up in the form of visible light. This is why we observe road signs, certain mineral specimens, and some dyes that are fluorescent.

The electron returns to the *V* band, giving up its energy in the form of a light photon. (See Figure 3.) The wave length of this photon is

longer (less energy) than the photon which originally caused the electron to be dislodged from the *V* band. This is evident because ultraviolet light caused the electron to leave the *V* band and another color, lower in frequency, is seen to be given off when electrons return.

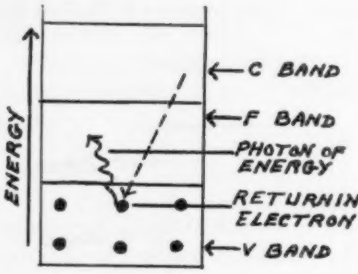

FIGURE 3

This is not contrary to the Law of Conservation of Energy because the energy differences between the photon leaving and the photon entering is lost in the form of heat generated by the electron and zinc-sulfide molecules.

Zinc sulfide, which is impure, that is, contains foreign atoms such as copper or silver, exhibits the property of phosphorescence. Electrons in

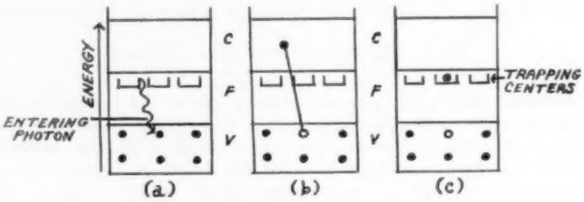

FIGURE 4

Figure 4(a). An incoming photon strikes an electron.
Figure 4(b). The electron absorbs energy from the photon and moves up to the C band.
Figure 4(c). In returning to the V band, the electron is caught in a trapping center and here it remains as long as the phosphor is kept on the dry ice.

the *V* band are struck by ultraviolet photons and are given sufficient energy to permit them to move to the *C* band as was previously pointed out. The impurity atoms in the *F* band as pictured in Figure 4 act as "trapping centers"; they make it difficult for the electron to return to the *V* band. The kinetic energy (heat energy) at room temperature is normally sufficient to cause these

"trapped" electrons to return to the V band. However, if the phosphor is cooled as was done in the experiment, then the electrons will be unable to return, for there is no source of energy great enough to release them from their traps.

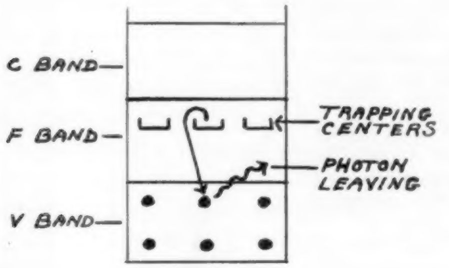

FIGURE 5

As the phosphor is warmed to body heat, the trapped electrons can acquire sufficient kinetic energy to escape the trapping centers and return to the V band. In so doing, a photon of visible light is emanated.

This is why glowing will not persist when the zinc-sulfide phosphor is placed on dry ice. When the phosphor is warmed to body temperature, the electrons are able to pick up the necessary energy to free themselves of the silver atom trap. Upon returning to the V band, they are able to release a photon of light energy. In this way light may be stored for a considerable length of time.

EXPERIMENT 2: THE PHOTOELECTRIC EFFECT

Purpose

To study how electrons can be made to leave a metal surface when it is bombarded by light energy.

Materials

An electroscope, a hard rubber comb or rod, a piece of wool or cat's fur, a piece of polished zinc, magnesium ribbon, some abrasive material such as jeweler's rouge to polish the zinc plate, a glass plate, and electrophorus (optional).

Procedure

Polish the zinc with jeweler's rouge or some other abrasive material. Insulate the zinc plate from the table top with an electrophorus. (If this is not available, you may simply wire the zinc plate to the knob on top of the electroscope. In this way it will be supported and also make electrical contact with the knob.) After securing a wire from the zinc plate to the electroscope knob, charge the electroscope with the rubber rod. This causes the leaves to diverge due to an excess negative charge. Ignite a piece of magnesium ribbon and let the light fall on the surface of the zinc. What happens? Place a piece of glass in front of the zinc plate before igniting another strip of magnesium. What happens the second time? See Figure 6.

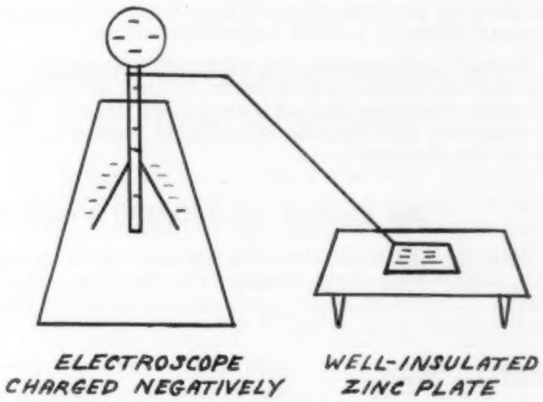

FIGURE 6

Discussion

The simplicity of this experiment should not obscure its importance in the development of the new ideas in physics. The theory now accepted for the convergence of the electroscope leaves that you observed when the magnesium ribbon was ignited is that photons (small bundles of light energy) strike electrons on the surface of the zinc and impart to them sufficient energy to escape from the surface of the metal. In this way the negative charge on the zinc plate is dissipated as electrons continue to stream off.

You may well ask why we must use a special light source to release these photoelectrons. Why is it not possible to use ordinary sunlight or incandescent light? The answer is that only ultraviolet light is able to release electrons from the surface of zinc. Burning magnesium is rich in this invisible ultraviolet radiation.

Ultraviolet light is of a higher frequency than visible light and therefore possesses more energy per photon. The following equation proposed by Einstein in 1905 summarizes this point of view very neatly. If h is a constant (called Planck's Constant) and v is the frequency of a certain light photon coming from the magnesium ribbon, then the energy E of the photon is given by the formula $E = hv$.

The important idea this equation conveys is that the energy of a photon is directly propor-

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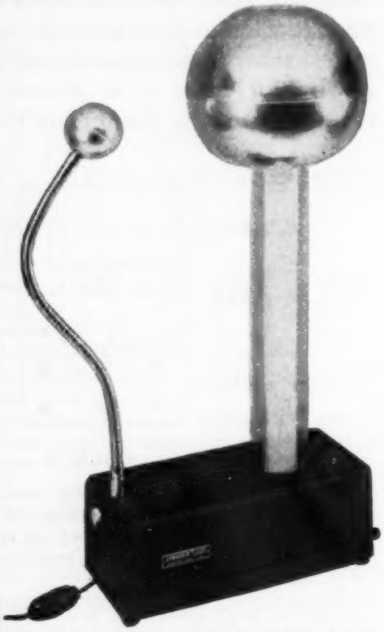

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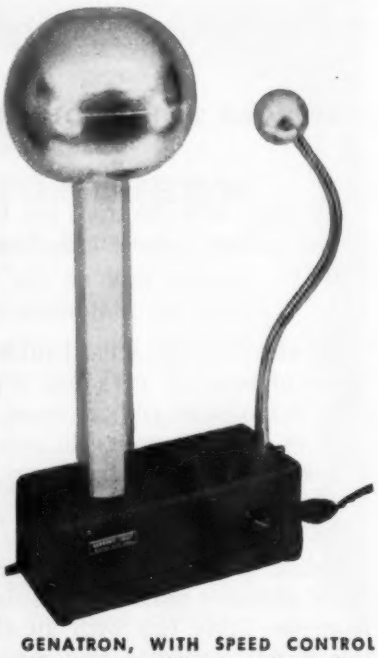

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tional to the frequency of the photon. In examining the visible spectrum we note that the frequency of red light is about 4 times 10^{14} vibrations per second. Violet light at the other end of the spectrum has a frequency of about 8 times 10^{14}. If these two values are substituted in Einstein's equation [$E = hv$], then we find that the energy of a photon of violet light is twice as energetic as a photon of red light. However, even this energy is not sufficient to release electrons from zinc. We must use ultraviolet photons which are more energetic to release electrons from zinc.

You may recall from your study of chemistry that zinc is a rather active metal because it tends to lose electrons easily. There are metals, if you will recall further, that are more active than zinc, that is, they tend to lose electrons more easily than zinc. Some of them are aluminum, magnesium, sodium, lithium, and calcium. Do you suppose these would also be good electron donors under the influence of ultraviolet light? You may want to try some of them. *Students should not use sodium or potassium except under supervision of a teacher.*

This experiment is quite important because it offered the first concrete evidence that light behaved as though it were made up of small units called photons. Prior to this it was accepted that light was transmitted much as water waves transmit energy. Since this experiment was first performed, there have been others to indicate the photon nature of light propagation. At present, physicists accept both explanations of light behavior as being valid because there is experimental evidence to support both theories.

SNOW CRYSTALS . . . Answers

(from page 533)

(1) Columnar Crystal (combination of bullets); (2) A Plane Crystal (broad branches, some have fernlike branches); (3) Combination of Column and Plane Crystals (bullets with plane-dendritic crystals); (4) A Rimed Crystal (Graupel-lump-like). For references see *Snow Crystals, Natural and Artificial.* By Ukichiro Nakaya. Harvard University Press, Cambridge, Mass. 1954. Also *Report of the Mauna Loa Expedition in the Winter of 1956-7.* By Ukichiro Nakaya, et al. The Munitalp Foundation, Inc., New York. May 1957.

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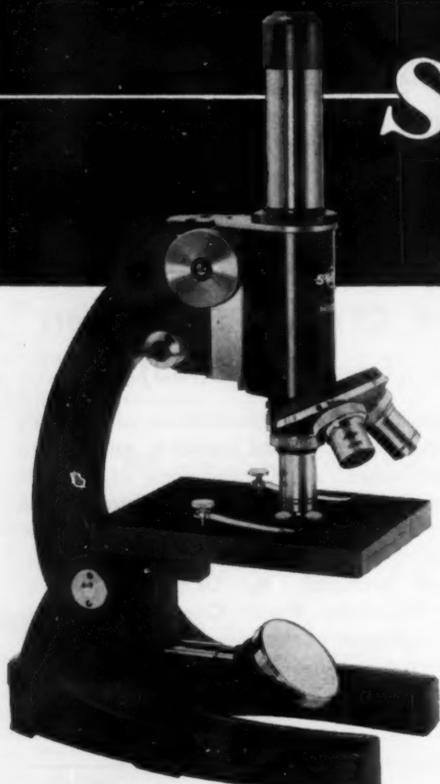

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NSTA Activities

Budget for 1959-60

The action program of NSTA for 1959-60 was published in the November *TST*. Financing such an extensive array of activities calls for careful planning, efficient management, and effective communication with individuals and groups who lend financial support. This year's budget estimates in summary form are as follows.

	Income	*Expenditures*
I. Science Education Activities for Youth	$ 76,000	
A. Future Scientists of America		$ 15,000
B. Science Achievement Awards		20,000
C. Special projects		21,000
I. Sub-totals	$ 76,000	$ 56,000
II. Professional Activities for Teachers	$215,000	
A. Periodicals, other publications		$ 79,000
B. Packet Service, Registry		51,000
C. Convention, other meetings		38,000
D. STAR Awards		31,000
E. Other		5,000
II. Sub-totals	$215,000	$204,000
III. NSTA Activities for Members	$109,000*	
A. Staff, Board, field service		$121,000
B. Operational expenses		53,000
C. Debt reduction and contingency		10,000
III. Sub-totals	$109,000	$184,000
Balance from 1958-59	$ 44,000	
Grand totals	$444,000	$444,000

* This sum, provided by payments of members and subscribers, equals 25 per cent of total budget.

NSTA Sections

A third member of NSTA's "family of sections" has appeared on the horizon. On October 29, the Association for the Education of Teachers in Science (AETS) voted to request sectional status, and this request will be acted on by the NSTA Board next summer. Established 40 years ago, AETS will continue its own program on an expanded scale; will also become NSTA's arm for teacher education, certification, and professional standards. Current officers of AETS include: Dr. Harold E. Tannenbaum, President, and Dr. Willard J. Jacobson, Secretary.

Now forming is the new Section for Supervisors, Consultants, and Coordinators. This was requested by the group in Atlantic City; and was authorized by the Board last July. The first Section of NSTA was the Business-Industry Section, which was launched in 1950.

Membership eligibility and opportunities in the two new Sections are now being defined; will be announced by next fall.

AAAS Meeting

The annual joint meeting of NSTA with other science teaching societies affiliated with the American Association for the Advancement of Science will be held this year at the Hotel Sherman in Chicago, Illinois, December 27-30. All who plan to attend should make hotel reservations by writing to the AAAS Housing Bureau, Suite 900, 134 North La Salle Street, Chicago 2, Illinois.

Details of the various sessions of the science teaching associations will be printed in full in a special section of the AAAS General Program; *no separate program for the science teaching groups will be mailed this year.*

Joint sessions involving NSTA and one or more of the other societies will include a general session on Sunday morning, December 27, and an elementary science session on Tuesday afternoon, December 29. An abbreviated program of all NSTA sessions is as follows:

Sunday, December 27

General Session—Man and Space Travel; George Bernard Shaw Room. 10 a.m.

Speaker: John A. O'Keefe, Associate Chief, Theoretical Division, Goddard Space Flight Center, National Aeornautical and Space Administration, Washington, D. C. "Surface of the Moon."

Speaker: James C. Fowler, Curator of Education, Cranbrook Institute of Science, Bloomfield Hills, Michigan. "The Place of Planetaria in Teaching Space Science." (See next page)

Concurrent Sessions—Here's How I Teach Space Science. 2 p.m.

A. Elementary School Level, Jade Room.
B. Junior High School Level, Gold Room.
C. Senior High School Level, Ruby Room.

Monday, December 28

Symposium on K-12 Planning—Presentations; Bal Tabarin Room. 9 a.m.
Symposium on K-12 Planning—Round Table Discussions; Bal Tabarin Room. 2 p.m.

Tuesday, December 29

Symposium on K-12 Planning—Summary of Round Table Discussions; Bal Tabarin Room. 10 a.m.
Staff and Committee Reports—"This Is Your NSTA"; Bal Tabarin Room. 11 a.m.
Joint Elementary Science Session; Assembly Room 2 p.m.

Wednesday, December 30

Conference on the Future Scientists of America Program; Jade Room. 9:30 a.m.

An invitational conference to provide opportunities for scientists to hear about, to discuss, and to counsel on the program of services and activities of the Future Scientists of America Foundation of the National Science Teachers Association. Special attention will be given to proposals for a Future Scientists of America Youth Activities Program.

All interested persons are welcome to attend.

European Tour, 1960

First major project of NSTA at the international level is scheduled for the summer of 1960—a 40-day European Science Tour. Since this is an official NSTA project and not a planned sightseeing venture, team members will have certain professional responsibilities to perform during the tour, and follow-up activities at its conclusion. Principal purposes: (1) to meet and confer with our counterparts in science teaching in other countries; (2) to visit elementary and secondary schools, colleges, and universities; survey room designs and science teaching facilities; (3) to visit places and institutions of special interest, historical or current; (4) to do some of the usual kinds of sightseeing. Planned with the cooperation of the NEA Travel Division and various scientific advisers, the NSTA "team" will make conference stopovers in London, Amsterdam, Bonn, Munich, Geneva, and Paris. Probable all-expense cost (except for lunch and dinner in London and Paris, 12 days): $1175. Full information available from NSTA headquarters upon request after December 10. The individuals who will be official members of the tour team will be notified of their selection by this office by March 1.

Membership Report

Growth in membership continues to be encouraging. Individual membership is over the 14,000 mark. Within this figure life membership has reached a total of 478, while student membership for this school year has reached 1368. Individual and group subscriptions now provide for a circulation of 35,000 copies of the *Elementary School Science Bulletin*. At this time of year, membership renewal statements and subscription renewal forms are being sent to remind all members and subscribers to renew orders promptly for 1960 so that interruptions in services and materials will not occur.

Beginning January 1960, a change will be made in the handling of membership subscriptions. The membership year will run one year from the date of the membership application received. This will affect only new members, however, and only those members who do not renew promptly.

We hope you like the convenience of our new renewal forms. At the headquarters office, prompt attention is given to renewals, changes of addresses, and changes in subscription quantities to insure the best possible service. Please let us hear from you, if your publications are not being received.

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FSA Activities

SAA, 1960

A wealth of ideas for student science projects will be found in the brochure which lists winners of awards and honorable mention in the 1959 program of Science Achievement Awards. A copy will be sent free to teachers requesting information and student entry forms for the 1960 program, which is now getting under way. Sponsored by the American Society for Metals since 1952, the SAA program in 1959 involved some 35,000 students. About 5000 submitted project reports and 220 received various awards totalling $14,000. Nearly 1800 were given certificates of Honorable Mention.

On-the-Job Research

Perhaps you or some of your bright young students have wondered how rare antibodies are detected in cattle serum; or, how the action of herbicides on cotton and oats is related to the different levels of nitrogen, postassium, phosphorus, and other minerals available to the plants.

If these questions have not crossed your mind, don't worry about it; they and other related problems will be subjected to research this year by two high school science teachers assisted by some of their prospective future scientists.

The two research projects described are being supported by financial grants provided by the Future Scientists of America Foundation to encourage research participation by high school science teachers. The recipients are Mr. Charles W. Anderson, who teaches in the high school at Norwood, Minnesota, and Mr. Hollis C. Fenn, a science teacher in the high school at Petersburg, Virginia. Mr. Anderson did preliminary work on his cattle serum project at the University of Wisconsin last summer and will continue, as in the past, to have Dr. W. H. Stone of that institution as his science consultant.

Assisting Mr. Fenn in his research on herbicides will be Dr. Donald E. Moreland of the Agricultural Research Service, U. S. Department of Agriculture, Raleigh, North Carolina. Mr. Fenn also began his study last summer as part of an NSF research participation program at North Carolina State College.

The provision of grants to encourage on-the-job research participation by high school science teachers is one of the major activities of FSAF this year. Funds are available to make a small number of grants ranging from about $250 upward. Teachers are encouraged to take advantage of this opportunity and to assist FSAF in a continuing pilot run of the validity of this idea. Further information on how to apply for a research grant to explore some problem you are interested in may be obtained by writing directly to NSTA headquarters.

FSA Youth Organization

After more than three years of study and evaluation, the NSTA Board of Directors has authorized the development of a science youth organization within the framework of NSTA and FSAF. Through this new organization, we hope to develop a program of services and activities which will be beneficial and practicable.

This organization will undoubtedly be called the *Future Scientists of America* (FSA), but the door is still wide open for all interested persons to suggest specifically how it should be organized, and what activities should be undertaken in the new program. Obvious questions about FSA range all the way from—shall there be pins or other insignia for identification, to questions as to dues, officers at local, state, and national levels, and appropriate kinds of student meetings and displays.

Following normal procedures and practices of NSTA, two inquiry forms have been mailed to representative samplings of the membership to seek their advice on the many aspects of this developing organization for students. Everyone is encouraged to consider seriously the benefits of such a program, what it should be, what it should do, and how organized or developed. Your comments and suggestions should be sent directly to NSTA headquarters.

Administrative Committee 1959-60

Dr. Alfred B. Garrett, Professor of Chemistry and Head of the Department of Chemistry at The Ohio State University, will serve as a member of the NSTA's Administrative Committee for FSAF. He will serve for one year to replace Dr. Harold Cassidy, Associate Professor of Chemistry, Yale University. Dr. Cassidy, who served on the committee for the last two years, has resigned due to the pressures of new responsibilities that entail extensive travel and other activity commitments.

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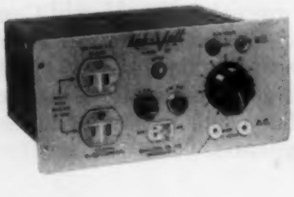

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Federal Support for Education

An NSTA Staff Report on the Murray-Metcalf Bill

In the circles in which we move, the question of whether the 86th Congress will pass a Federal school support bill is of top concern. Those we associate with are, of course, overwhelmingly favorable to the principle at issue. And most are firmly convinced that the Congress *can* pass such a bill—*if the teachers and parents of school-age children will speak up and let their views be known* through letters and other sources.

Dozens of designs for school assistance from the Federal Government have been proposed. The leading bill now under consideration was introduced early in the first session by Senator James E. Murray (D-Mont.) and Representative Lee Metcalf (D-Mont.) and a group of cosponsors. This bill is described as:

A bill to provide financial assistance for the support of public schools by appropriating funds to the states to be used for constructing school facilities and for teachers' salaries.

This act may be cited as the "School Support Act of 1959."

Taking cognizance of long-existing inadequacies that have produced crowded conditions, double sessions, and low teachers' salaries in so many instances, the bill recommends action in this area.

If enacted into law, the Murray-Metcalf Bill would make Federal funds available to the states in line with the provisions summarized below.

The National Science Teachers Association, by action of its Board of Directors, has supported the principle of Federal assistance for education on numerous occasions.

Recent examples of effective Federal assistance are the support of science education through the National Science Foundation and the funds made available through the National Defense Education Act of 1958.

The two parent organizations with which NSTA cooperates have indicated their support of the Federal assistance plan. A strong stand for this principle has long been the policy of the National Education Association.

The American Association for the Advancement of Science supported this principle by resolution of its Council in 1959 as follows: "The Council of the AAAS welcomes the NDEA of 1958 as further confirmation of the principle that the Federal Government should share the responsibility for the support of education." In addition, White House conferences on children and youth have repeatedly urged Federal support, at least since the 1930 conference which was convened under President Hoover.

Science teachers, as well as all citizens of the U.S. are, of course, free agents in determining their own attitudes toward the question of Federal support for schools. Our purposes in preparing this *TST* report are to emphasize the needs of our schools, to present some of the salient facts about the Murray-Metcalf Bill, and to call attention to sources of support for the principle. We urge everyone to examine and study this bill in the light of what it would do to enhance quality education in his state and community, and then take appropriate action.

If possible, write a letter expressing your views to your senator or congressman on the need for Federal financial support for education.

SUMMARY

The Congress finds that despite sustained and vigorous efforts by the state and local communities, which have increased current school construction to unprecedented levels and which have increased expenditures for teachers' salaries, there is still a serious shortage of classrooms and of qualified teachers which requires immediate action on the part of the Federal Government.

The Congress strongly affirms that the control of the personnel, program of instruction, formulation of policy, and the administration of the nation's public elementary and secondary schools resides in the states and local communities. The Congress also affirms that a major portion of the responsibility to finance the costs of these schools resides in the states and local communities.

However, the Congress recognizes that without sufficient financial resources at their disposal to provide necessary educational facilities and to employ competent teaching personnel, the control of our nation's schools is not directed by state and local school boards but is dictated by the harsh demands of privation. Without the means to pay for alternatives, school boards have no freedom of choice.

The purpose of this act, therefore, is to provide Federal financial support to help meet both the immediate and

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continuing problems of financing adequate school facilities and teachers' salaries and thereby to strengthen the schools of the nation.

Authorization of Appropriations

There are hereby authorized to be appropriated for the fiscal year beginning July 1, 1959, and for succeeding fiscal years, amounts equal to the product of the estimated number of the school-age population of all the states as of such year and the following amounts: For the fiscal year beginning July 1, 1959, \$25; for the fiscal year beginning July 1, 1960, \$50; for the fiscal year beginning July 1, 1961, \$75; and for each fiscal year thereafter, \$100.

The state education agency of each state which desires to receive an allotment under the provisions of this act shall specify annually to the Commissioner the proportion of its state's allotment that will be expended for each of the two purposes: (1) school construction and (2) teachers' salaries.

The state education agency shall verify annually to the Commissioner that funds received under this act were distributed and expended in accordance with the provisions of this act.

Maintenance of State and Local Financial Support of Schools

The amount allotted to any state under section 4 for any year shall be reduced by the percentage (if any) by which its state school effort index for such year is less than the national school effort index for such year, with the exception that during the first three years that allotments are made this provision shall not be applicable. The total of such reductions shall be reallotted among the remaining states by proportionately increasing the amounts allotted to them under section 4 for such year.

Assurance Against Federal Interference in Schools

In the administration of this Act, no department, agency, officer, or employee of the United States shall exercise any direction, supervision, or control over policy determination, personnel, curriculum, program of instruction, or the administration of any school or school system.

Definitions

The term "Commissioner" means the United States Commissioner of Education.

The term "state" means a state, Hawaii, Puerto Rico, Guam, Virgin Islands, Wake Island, American Samoa, or the District of Columbia.

The term "state education agency" means the state board of education or other agency or officer primarily responsible for the state supervision of public elementary and secondary schools, or, if there is no such officer or agency, an officer or agency designated by the governor or by state law.

The term "school district" means any public-school administrative unit in a city, county, township, school district or other political subdivision in a state that is under the direction of a board of education or other legally constituted local school authority having administrative control and direction over tax-supported public education.

The term "school facilities" means classrooms and related facilities (including furniture, equipment, machinery, and utilities necessary or appropriate for school purposes) for education which is provided by a school district for elementary or secondary education, in the applicable state, at public expense and under public supervision and direction; and interests in land (including site, grading, and improvement) on which such facilities are constructed.

The term "school-age population" means that part of the population which is between the ages of 5 and 17, both inclusive, as determined on the basis of either the actual or estimated population between such ages for the most recent year for which satisfactory data are available from the Department of Commerce.

The term "teacher" means any member of the instructional staff of a public school district as defined by the education agency of each state.

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SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee
Dr. Robert A. Bullington, Chairman
Northern Illinois University, Dekalb

BOOK BRIEFS

Basic Physics for Secondary Schools. Howard L. Eubank, John M. Ramsay, and Leslie A. Rickhard. 416p. $3. The Macmillan Company of Canada Limited, Toronto, Ontario. (U. S. distributor: St. Martin's Press, 103 Park Ave., New York 17, N. Y.) 1957. Reprinted with corrections, 1958.

This text attempts to give an insight into a few fundamentals of the subject and an understanding of some of its applications. Presented in a clear and concise manner. The need for accuracy and precision in making observations, taking measurements, making calculations and reaching conclusions, is constantly emphasized. All sections are quite complete except for Mechanics. Here there is no discussion of force and motion, kinetic and potential energy, Newton's laws, simple machines, or some other topics. One valuable feature is the inclusion of experiments for each section, so that the book may be used as a laboratory manual as well as a textbook.

Laboratory Experiences for Students of Physical Science. Olaf P. Anfinson. 109p. $2.15. Wm. C. Brown Co., 135 South Locust, Dubuque, Iowa. 1959.

A laboratory manual and workbook designed for a one-semester integrated physical science course for the general education of non-science majors in college. Includes sixteen exercises organized into four units. Designed to guide students into problem situations with a minimum of specialized equipment and within the limited mathematical and manipulative abilities of the non-science student.

The World of the Microscope. L. J. Ludovici. 128p. $2.95. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

Describes the important discoveries in the invisible world of the microbe. Dramatically presents the achievements of Jenner, Pasteur, Lister, Koch, Reed, Fleming, and Salk. Points out the beneficial aspect of microbes and the history of the miracle drugs. Well-written to hold the interest of junior high school readers.

Space Satellites. Lloyd Mallon. 144p. 75¢. Fawcett Books, 67 West 44 St., New York 36, N. Y. 1958.

This paper-bound book is presented at the secondary-school level. The illustrations and text on satellites are self-explanatory. An effective reference. A similar book by the same author on a different topic is *A Guide to Astronomy*.

Radioastronomy and Radar. J. G. Crowther. 64p. 10s6d net (or about $1.25+). Methuen and Company, Limited, 36 Essex St., Strand, London, England WC2. 1958.

This book presents in graphic fashion the physical principles involved in radioastronomy. The diagrams and drawings are well correlated with the text. Understandable to students in secondary schools and junior colleges.

Guide to Rockets, Missiles, and Satellites. Homer E., Newell, Jr. 54p. $2.50. McGraw-Hill Book Company, Inc., 330 West 42 Street, New York 36, New York. 1958.

This book gives descriptions of 75 rockets, missiles, and satellites, listed alphabetically. It is a practical book for students to acquaint themselves with these jet devices. It can be used by students in upper elementary and high school grades. It contains pertinent statistics on aircraft.

Man: His First Million Years. Ashley Montagu, 192p. 50¢. A Mentor Book. The New American Library, 501 Madison Ave., New York 22, N. Y. 1958.

An excellent, informative book concerning the origin of man. This book gives authoritative insight into both cultural and physical anthropology. Should appeal to a wide range of readers and be particularly good for high school and early college use.

Look for a Bird's Nest. Robert Scharff. 96p. $2.75. G. P. Putnam's Sons, 210 Madison Ave., New York 16, Madison Ave., New York 22, N. Y. 1958.

An interesting little book dealing with all phases of bird's nests. Where are they found? What are they made of? How are they built? Nicely illustrated with 40-line drawings. Challenging and enjoyable reading from junior high to adult level. Useful to those who collect bird's nests as a hobby.

MEN AT WORK ON THE WEST COAST. Henry B. Lent. 125p. \$3. G. P. Putnam's Sons, 210 Madison Ave., New York 16, N. Y. 1959.

Regional survey of important industries on West Coast. Discusses mining methods of petroleum and borax industries. Agricultural activities of grape, almond, cotton, orange, vegetable, and fruit growers are depicted. Paper mills, movie industry, commercial fishing, canning, and aircraft industries are also covered. Recommended for ages 8-12.

MODERN HIGH SCHOOL BIOLOGY—A RECOMMENDED COURSE OF STUDY. Dorothy F. Stone. 96p. \$1.50. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. 1959.

Monographs in a series. By the Science Manpower Project of Teachers College, Columbia University. Omission of certain topics provides time for study of others in greater depth. Titles of units are Chemical and Physical Aspects of Life, Structure and Function of Living Things, Intra- and Interdependencies of Life, Reproduction, Genetics, and Changing Things.

TEACHING SCIENCE IN TODAY'S SECONDARY SCHOOLS. Walter A. Thurber and Alfred T. Collette. 640p. \$6.95. Allyn and Bacon, Inc., 150 Tremont St., Boston 11, Mass. 1959.

Contents include chapters on such problems in secondary science education as bringing the community into the classroom, use of television, planning a new science program, setting up a six-year science sequence, and emphasizing the quantitative aspects of science.

HOW TO STUDY SCIENCE. Louis Haber and Lawrence Samuels. 81p. Single copy \$1; quantity order 60¢ per copy. College Entrance Publications, 104 Fifth Ave., New York 11, N. Y. 1959.

A valuable booklet for the science student and useful to the teacher. Gives suggestions on studying science, preparing textbook assignments, taking notes, doing and reporting experiments, remembering science information, mastering word meanings, taking examinations, securing information, and preparing reports. Based on experience of the authors.

CHLOROPLAST PIGMENTS AND CHROMATOGRAPHIC ANALYSIS (Thirty-Second Annual Priestley Lecture). Harold H. Strain. 180p. \$2.75. Phi Lambda Upsilon, Department of Chemistry, The Pennsylvania State University, University Park, Pa. 1958.

This paper-bound, manual-sized book contains specific directions for effecting chromatographic separations of the various chloroplast pigments. References to the original research papers and technical books are found at the end of each chapter. Electrochromatography is treated, as well as several other modifications of the basic chromatographic technique. This content alone is sufficient to recommend the book to advanced biology classes and to students interested in preparing science fair projects. The appendices, containing pigment analyses of a great number of plants from all levels of complexity in the plant kingdom, are of significance in providing biochemical criteria of relations between various groups in the plant kingdom.

WATER AND THE CYCLE OF LIFE. Joseph A. Cocannouer. 143p. \$3. Devin-Adair Company, 23 East 26 St., New York 10, N. Y. 1958.

A well-qualified author has made a real contribution to nontechnical conservation literature for the high school student, teacher, and general reader. Shows the importance of quality water to soil, plants, animals, and man. Water cycle is traced in detail. Ecological relationships are stressed. Based on extensive experience of author.

SCIENCE MATERIALS—PREPARATION AND EXHIBITION FOR THE CLASSROOM. Gordon G. Pond. 132p. \$2.75. Wm. C. Brown Company, 135 South Locust, Dubuque, Iowa. 1959.

The science teacher and the student working on a project will find this a valuable reference, for it will give information on many common problems that face them. Covers details of the preparation of many kinds of biological and geological materials for preservation and display. Can be used as a classroom reference or as a text. Illustrated with excellent photographs. Paper cover, spiral binding, manual size.

WOODY PLANTS IN WINTER. Earl L. Core and Nelle P. Ammons. 218p. Paper \$2,75, cloth \$4. The Boxwood Press, Box 7171, Pittsburgh 13, Pa. 1958.

A convenient handbook for all botanists. There has been a need for a manual of this type for use by elementary botany and taxonomy students on winter field

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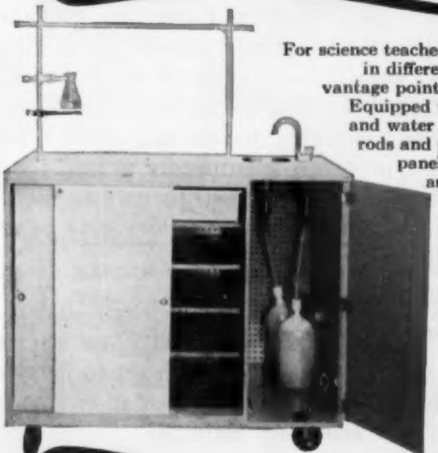

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trips. Includes a discussion of woody stem morphology, a key to genera, the description and distribution of important species of northeast United States and southeast Canada, and a glossary. The many line drawings of important key characteristics are good and useful.

SKY SENTRY. Arnold Brophy. $2.75. Dodd, Mead & Company, New York 16, N. Y. 1959.

A veteran newspaperman and author of *The Air Force* has written about the Strategic Air Command (SAC)—how it works, what it does, and the training SAC crewmen receive. Material for the story is based on the experiences of a combat SAC crewman. Contains 65 photographs and is well written. Its accuracy has been checked by SAC Headquarters, USAF Headquarters, and the Department of Defense. Suitable for high school use.

PROFESSIONAL READING

"Teaching Science by Television." By Maurice V. Ames. *The Clearing House,* 34:6. September 1959. Conclusions about ETV reached as a result of observations on visits to ten cities where projects are being carried on.

"Audio-Visual Materials for Space-Age Science." By Lester B. Sands. *Grade Teacher,* 77:46. October 1959. Four logical stages of aviation history to explain space travel and materials for teaching.

"History of the Cyclotron." Part I by Dr. M. Stanley Livingston, Part II by Dr. Edwin M. McMillan. *Physics Today,* 12:18-33. October 1959. A complete history of the cyclotron from the 1930 paper of Lawrence and Edlefsen on the magnetic resonance accelerator to the 184-inch cyclotron housed today at the Lawrence Radiation Laboratory. The photographs depict the features and development as well as the scientist concerned in this program. The articles were done as a tribute to the late Dr. Ernest Orlando Lawrence.

"The Duluth Conference." *GeoTimes,* 4:20-23. October 1959. A pictorial report of the conference of geologists, science educators, and science teachers that was held in the summer of 1959 at the University of Minnesota at Duluth. The conference prepared two sourcebooks for secondary school; one sourcebook is on subject matter

(See page 603)

Specialist for Science Clubs Named

Mr. A. Neal Shedd has recently been appointed to the U. S. Office of Education as a Specialist for Science Clubs. His new duties involve the planning for the administration of the new Wright Bill, Public Law 85-875. The bill is designed to strengthen future scientific accomplishment through school science clubs, fairs, and other activities.

Mr. Shedd has been Supervisor of Science for the Fairfax County Public Schools, Fairfax, Virginia, for the past two years and previously was a classroom teacher and administrator for seven years in the Arlington County Public Schools, Arlington, Virginia.

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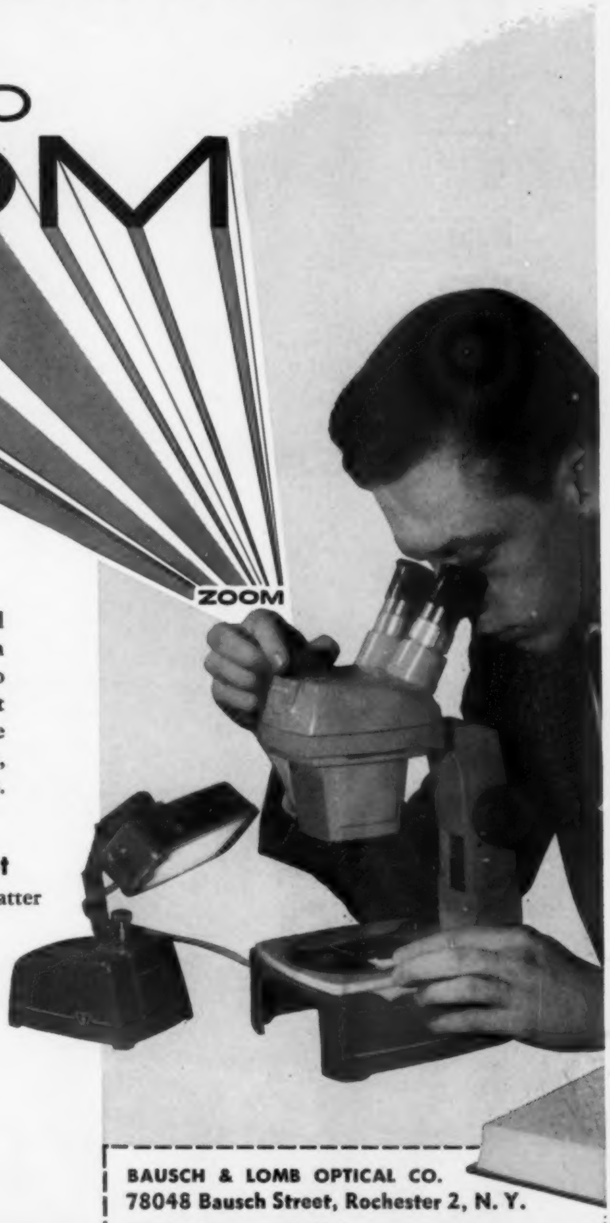

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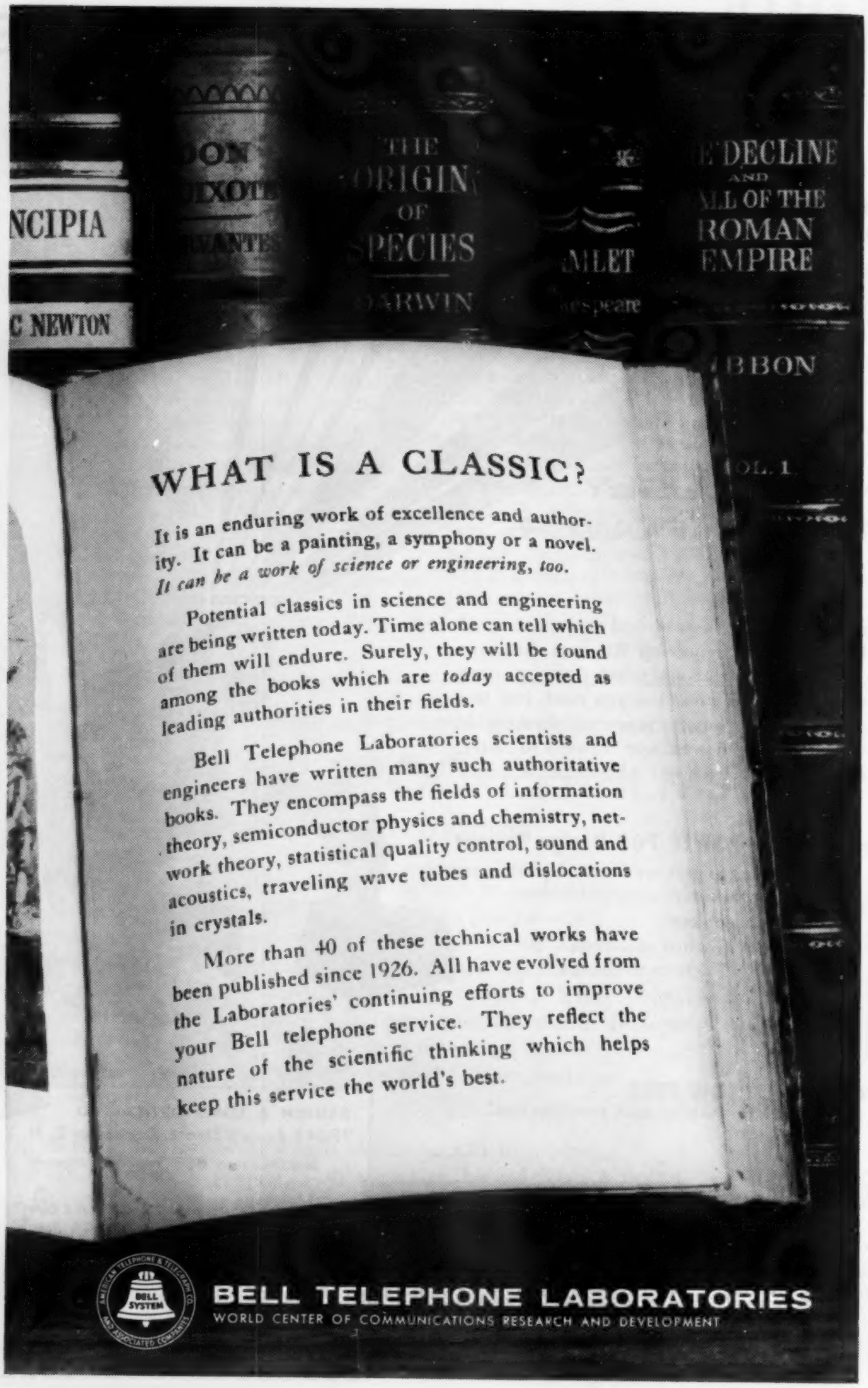
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and the other is a general reference sourcebook. The article reports the activities and findings of the conference.

"The Role of the Big Accelerators." By J. Robert Oppenheimer. *Think,* 10:8-11. October 1959. Discussion of why we are busily constructing bigger particle accelerators and what we can learn from them. The point of view experienced is that of a noted scientist, but the article is written for public consumption.

"Weather." By Franklyn M. Branley. *Grade Teacher,* 77:54. October 1959. Suggestions and materials for teaching about weather.

"The Values of Science Bulletin Boards." By Russell F. Scheicher. *Grade Teacher,* 77:55. October 1959. Help in using this often-neglected teaching aid.

"The Training of Science Teachers in the Departments of Education, Manchester University." By Frank Corner. *Science Education,* 43:228. April 1959. Describes university degree courses in science, professional training, practice teaching, and examinations in a British university.

"Physical Sciences in Our Secondary Schools." By Samuel R. Powers. *American Journal of Physics,* 6:419-423. September 1959. The early recognition of physical science, enrollment trends, and teacher education are covered in this article. New developments in physical sciences courses and in teacher preparation are suggested also.

"Science in Elementary Schools." By John P. Novarra. *American Journal of Physics,* 6:424-426. September 1959. Science is being taken into our elementary schools as an "intrinsic facet" of elementary education. The author discusses the emergence of science in the elementary school, curriculum, and objectives.

Excellent articles for your review appear in *Education,* 80:3-28. September 1959. The series entitled "Science Education" was especially written to give a well-rounded discussion of the important problems for provision of science instruction in elementary and secondary schools.

APPARATUS AND EQUIPMENT

CALCULO ANALOG COMPUTER KIT. An easily-assembled device in sturdy cardboard box, powered by flashlight batteries, and containing three potentiometers, a galvanometer, switch, and three dials with six sets of scales. Includes a well-written 48-page manual of explanation, instructions, and sample problems. An excellent introduction to basic elements of analog computers, the nature of electrical circuits, and many fundamental principles of mathematics. $16.95. Science Materials Center, 59 Fourth Ave., New York 3, N. Y. 1959.

AUDIO-VISUAL AIDS

THE WORLD OF MOLECULES. A most interesting introduction to the unseen world of molecules for use in science for the middle grades. Presented in a manner that allows the child to form concepts of molecular activity, size, and behavior under various conditions. 11 min. Color $110, B&W $60. 1959. Churchill-Wexler Film Productions, 801 North Seward St., Los Angeles 38, Calif.

NITROGEN AND AMMONIA. An up-to-date and time-saving aid for high school and college chemistry. Covers occurrence, properties, preparation, and uses of nitrogen and ammonia. 16 min. Color $165, B&W $90. 1959. Coronet Films, Coronet Building, Chicago 1, Ill.

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Readers' Column . . . from page 533

unthinkable to consider it could be viewed in any other terms, for physics is the study of that physical world and what we are able to observe happening within it. Any course in physics that would attempt to divorce the two is doing nothing more than inviting the inevitable—intellectual suicide. The important issue in PSSC is first the mastering of these fundamental principles, as revealed to us through the physical world, and secondly, the application of them to new physical situations of a meaningful nature.

"In closing, I can say I agree with only one item in the Barish letter—his expression that there is 'a need for a revised course in physics.' This revision, I believe, is well under way in the form of the PSSC physics course. There are revisions to be made as a result of practical experience gained in teaching the course which is now being done by those teaching it.

"(3) Mr. Barish invites the use of 'plug-in' problems in high school science courses to effect further use of the high school algebra learned. I am certain that math teachers in our high schools do not consider the ultimate goal in the mastery of algebra is reached when former students have proved their proficiency with 'plug-in' types of problems in science courses. If all mathematics departments in our secondary schools are aiming toward this mastery of 'plug-in' problems, automatic calculators could be built and maintained at much cheaper rates to perform this type of mechanical operation, while at the same time saving the student from further taxation of his mental thought processes."

John McGavack, Jr.
Glastonbury High School
Glastonbury, Connecticut

"I attended an NSF Institute at Bowdoin during the summer of 1958 in preparation for teaching the PSSC course. I taught it during the school year 1958-59 to a group of 48 students, and am teaching it this year to a group of 53 students. Under (1) of the Barish letter, I agree that some of the language and concepts are difficult, but not too difficult for the top 25 per cent of the high school population. This group has the intellectual capacity for grasping the course; if there is a lack of success with the course, it comes from a lack of willingness to wrestle with difficult problems until they are understood. We as teachers too often fail to develop in our students the 'toughness of mind' needed for respectable academic achievement. The texts were written by college teachers; however, the preparation of the texts was carried on under the constant scrutiny of high school teachers. Teachers of the large test group last year were urged strongly to keep a steady flow of criticism to the central committee, and the final form of the text for the course will reflect close cooperation between college and high school teachers. Finally, the PSSC course represents a major effort to improve education and deserves a thorough trial. It will be some months before we know how successful it is. It is a step in the right direction, and we plan to continue to offer the course in our school in addition to the traditional high school physics course."

John H. Dodge
Coordinator of Science
West Irondequoit Public Schools
Rochester, New York

"Permit me to express an emphatic 100 per cent accord with the views of the Barish letter. For the record, I have taught eight years in high school science and math, five years at a University as Chairman of a Civil Engineering Department, and eight more years of teaching high school science, five classes in physics actually."

Brother George J. Spahn, S.M.
Chairman, Science Department
Chaminade High School
Mineola, New York

"It was a relief to hear some criticism of PSSC. Much of what I have seen of it seems way over the heads of most of my students who are struggling to grasp the concepts of standard physics."

Paul C. Staples
Manchester, Massachusetts

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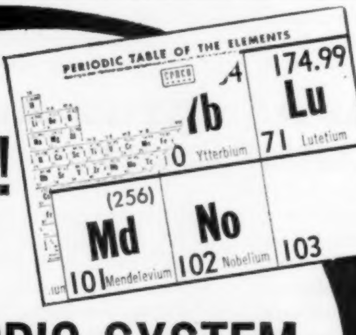

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Volume 26, THE SCIENCE TEACHER

Index—February through December 1959

The annual index is designed to be functional and space-conserving. Listed alphabetically by authors, the individual articles are coded according to topic category in bold-face figures. The key to the codings appears at the bottom of each page.

(1) Conservation (2) Education of Science Teachers (3) Elementary School Science (4) Experiments, Demonstrations, and Pupil Projects and Activities (5) History, Philosophy, Goals, and Objectives (6) Information for Science Teachers (7) Instructional Suggestions, Methods, and Materials (8) Investigations, Research, and Fact-finding Studies (9) Science Clubs, Fairs, and Exhibits; Science Talent Searches (10) Science Course Content, Organization, and Curriculum

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NSTA Activities

(1) Conservation (2) Education of Science Teachers (3) Elementary School Science (4) Experiments, Demonstrations, and Pupil Projects and Activities (5) History, Philosophy, Goals, and Objectives (6) Information for Science Teachers (7) Instructional Suggestions, Methods, and Materials (8) Investigations, Research, and Fact-finding Studies (9) Science Clubs, Fairs, and Exhibits; Science Talent Searches (10) Science Course Content, Organization, and Curriculum

FSA Activities

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor as early as possible.

December 26-31, 1959: NSTA Annual Winter Meeting with science teaching societies affiliated with the American Association for the Advancement of Science, Hotel Sherman, Chicago, Illinois

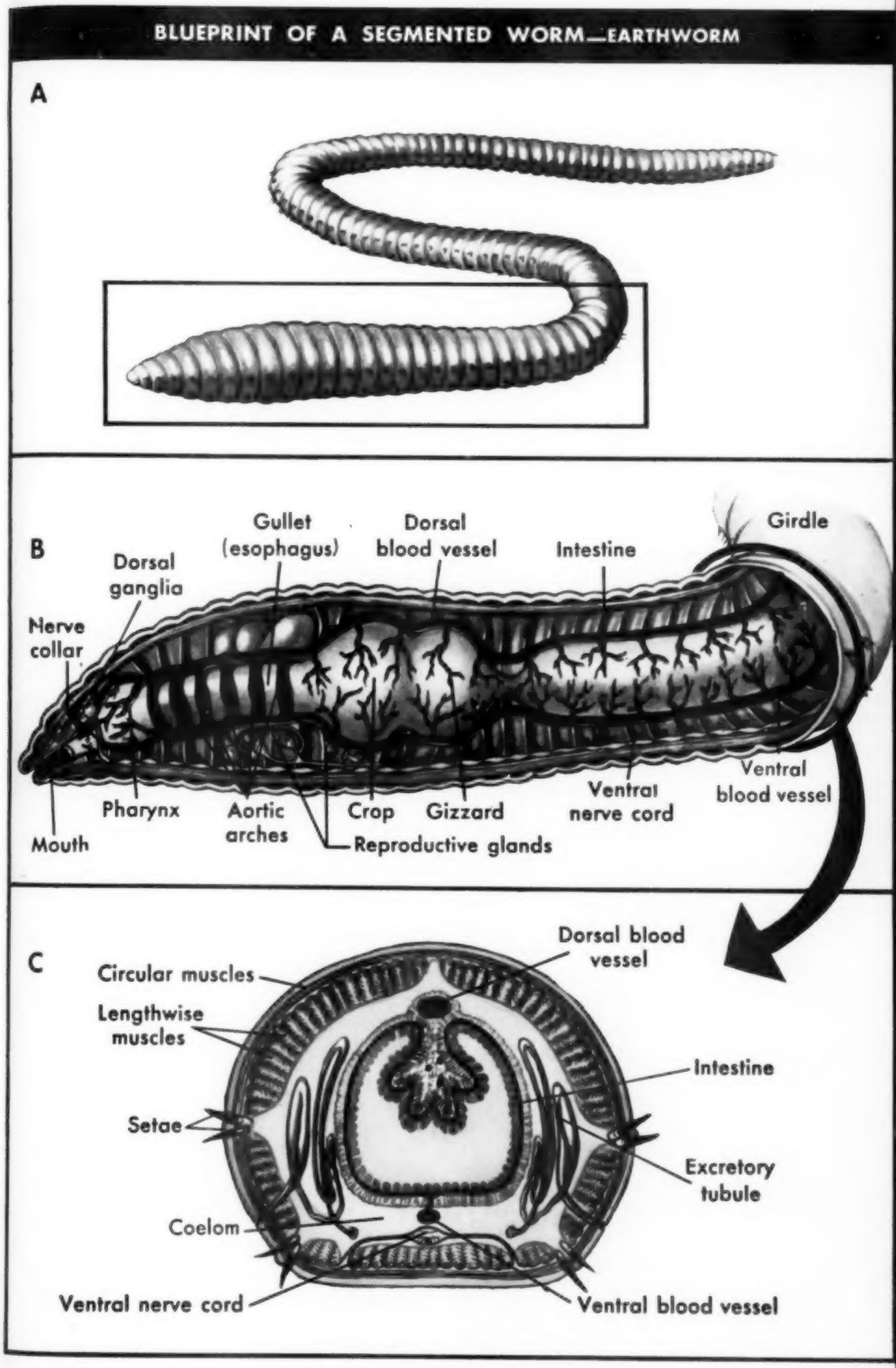
January 28-30, 1960: 29th Annual Meeting, American Association of Physics Teachers, Hotel New Yorker, New York City

February 10-13, 1960: 33rd Annual Meeting, National Association for Research in Science Teaching, Chicago, Illinois

March 29-April 2, 1960: NSTA Eighth National Convention, Muehlebach and Phillips Hotels, Kansas City, Missouri

Index of Advertisers

1/763 of a new high school biology text that merits careful attention



One of the many teaching charts that illustrate the increasing phylogenetic complexity of living things, and, at the same time, help students in their practical work in the laboratory and classroom. A similar treatment is given to other major organisms to help students appreciate the unity in the vast diversity of life. These "blueprints" will be available on strip film (at a small cost) for showing as wall charts with a standard filmstrip projector.

Illustration from the new 763-page EXPLORING BIOLOGY: THE SCIENCE OF LIVING THINGS *(where it appears on page 191 in two colors and slightly larger)*

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